Idaho's landscape-scale wetland condition assessment tool—Methods and applications in conservation and restoration planning

Wildlife
and
Information Systems
Bureaus

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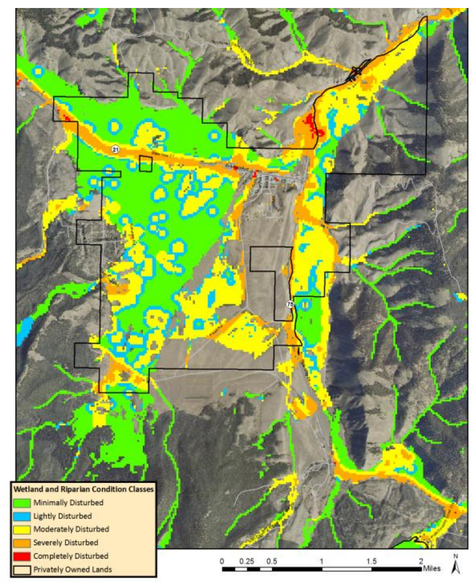

Wetland condition, Stanley, Idaho

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ABSTRACT

Landscape-scale land uses and stressors from human activities affect the integrity of ecosystems. The intensity of development and proportion of human land use interact to determine wetland condition at finer spatial scales. Based on this premise, Idaho Department of Fish and Game (IDFG) received a Wetland Program Development Grant from the US Environmental Protection Agency to use GIS to build a statewide raster-based landscape integrity model to predict wetland condition. Existing spatial layers of stressors known to directly and indirectly affect wetland condition were used, including land use (e.g., urban, agriculture, forestry, etc.), development (e.g., roads, railroads, utilities, mining, industrial sites, dairies, recreation sites, etc.), and hydrologic alteration (e.g., density of canals, wells, reservoirs, etc.). We also created a map showing the potential distribution of wetland and riparian habitats in Idaho. This raster layer was built by compiling all existing wetland, riparian, and hydrographic maps (e.g., land cover, National Wetlands Inventory, National Hydrographic Dataset, etc.). This layer was combined with the landscape integrity model to create a landscape-scale wetland assessment tool for Idaho. Site level field-generated rapid assessments of wetland condition were used to test accuracy of landscape-scale assessment results. The wetland assessment tool correctly predicted condition of field assessed wetlands 63% of the time. The tool's real-world application was demonstrated in 5 case studies of wetland conservation and restoration planning with governmental and non-governmental partners, including:

- development of a wetland and riparian restoration strategy for the Boise and Payette River basins (partner Trout Unlimited);
- identification of important wetland and riparian resources to inform land-use planning in the Upper Salmon River basin (partner City of Stanley);
- prioritization of potential wetland protection and restoration sites in the Upper Snake River region which is undergoing urban development (partner Teton Regional Land Trust);
- condition assessment and distribution of spring and vernal pool habitats in southern Idaho to inform revision of the State Wildlife Action Plan (partner IDFG, Wildlife Diversity Program);
- conservation prioritization of wetland complexes as part of the Statewide Comprehensive Outdoor Recreation and Tourism Plan (partner Idaho Department of Parks and Recreation).

KEYWORDS

condition, GIS, Idaho, landscape integrity model, landscape-scale assessment, mapped potential distribution, stressors, riparian, wetlands, wetland assessment

SUGGESTED CITATION

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INTRODUCTION

Wetlands provide functions and values greatly disproportionate to the small land area they occupy in the Intermountain West. From 1780 to 1980, approximately 56% (156,200 ha [386,000 ac]) of Idaho's wetlands were lost to drainage, dredging, filling, leveling, flooding, and other anthropogenic alterations (Dahl 1990). Areas of Idaho have experienced even greater wetland losses, mainly due to drainage for agriculture, and the condition of other wetlands has been degraded (Quigley et al. 1999). Due to strengthened wetland regulations, policies, and conservation (USFWS 1990, 1991), the rate of wetland loss has decreased during the last 25 years (Dahl 2000, 2006, 2011). Wetland assessment strives to determine ecological integrity, or condition, as well as function, in context of human land use and natural disturbance (US EPA 2006).

Wetland assessment, at multiple-spatial scales, feeds information to decision makers, land managers, and stakeholders that is useful for implementing regulations, policies, and conservation programs. At the broadest level, landscape-scale assessment is commonly used for assessing the condition, extent, and distribution of watersheds and wetlands (Brooks et al. 2002, Tiner 2002, Hychka et al. 2007, Mita et al. 2007, Troelstrup and Stueven 2007, Wardrop et al. 2007, Weller et al. 2007, Vance 2009, Murphy and Schmidt 2010, Lemly et al. 2011). The U. S. Environmental Protection Agency's (EPA) emphasizes a three-tiered approach to wetland monitoring and assessment, with Level 1 focused on landscape-scale analysis (US EPA 2006). The 2007 Idaho Wetland Conservation Strategy includes landscape-scale assessment as an important element of Idaho's monitoring and assessment program.

Landscape-scale assessment is defined as the use of a geographic information system (GIS) and remote sensing to understand the characteristics of watersheds and wetlands across a landscape of interest. Typical assessment indicators include wetland coverage, land use, land cover, and human disturbance (US EPA 2006). These indicators are typically incorporated into a GIS model of landscape integrity that is then used to estimate condition. Indicators can be based on expert judgment or systematically evaluated based on analysis of on-the-ground condition data (Gergel et al. 2002, Brooks et al. 2004, Hychka et al. 2007, Mita et al. 2007, Troelstrup and Stueven 2007, Wardrop et al. 2007, Weller et al. 2007, Vance 2009, Murphy and Schmidt 2010, Comer and Hak 2012). Regardless of methods used, landscape-scale assessment is a relatively low-effort method that maximizes the quantity, quality, and consistency of wetland data gathered over broad geographic areas (Hychka et al. 2007, Wardrop et al. 2007, Weller et al. 2007, Vance 2009, Murphy and Schmidt 2010, Lemly et al. 2011).

Several landscape-scale GIS analyses of ecological condition have been conducted for Idaho (Quigley et al. 1999; Bdour et al. 2001; Oechsli and Frissell 2003; Idaho Conservation Data Center 2006 and 2007; Trout Unlimited 2009; Murphy and Schmidt 2010). These have mostly focused on watershed integrity and aquatic habitats rather than wetland condition. Nationwide landscape assessments of wetlands have focused on wetland extent, not condition (Dahl 1990, 2000, 2006, and 2011). Prior to this project, the only broad-scale analysis of Idaho's wetlands that integrated wetland significance, threats, and condition were the "Idaho Wetland Conservation Prioritization Plan" (Hahn et al. 2005) and a prototype landscape-scale assessment (Murphy and Schmidt 2010).

In 2007, Idaho Department of Fish and Game (IDFG) received a Wetland Program Development Grant (WPDG) from the U. S. Environmental Protection Agency (EPA) under Section 104 (b)(3) of the Clean Water Act to build a prototype landscape-scale wetland assessment tool (Phase I) (Murphy and Schmidt 2010). It was developed and tested in northern and southwest Idaho in 2008 and completed during 2009. Murphy and Schmidt (2010) used analytical methods to correlate landscape-level stressor metrics with wetland condition. However, the prototype assessment tool was built using Analytical Tools Interface for Landscape Assessments (ATtILA) (Ebert and Wade 2000), an outdated ArcView 3.x extension in GIS. National Wetlands Inventory (NWI) polygons (Cowardin et al. 1979) were the units assessed by ATtILA. Ultimately, ATtILA was difficult to apply at the NWI polygon scale and unable to calculate condition metrics for over 3% of polygons (Murphy and Schmidt 2010). Moreover, results appeared influenced by polygon size, with the condition of large lakes and long riverine wetlands not as accurately assessed as small to mid-sized wetlands. When combined with inaccurate and incomplete NWI coverage in Idaho, the prototype model did not meet goals for accurately predicting wetland condition when compared to reference field-based observations of condition. Revisions were needed before the tool could be applied across Idaho.

In 2008, IDFG was awarded another WPDG to revise the prototype landscape-scale wetland assessment tool and demonstrate its application in real wetland planning and restoration scenarios (Phase II). By working with partners actively involved in wetland conservation, mitigation, and restoration, the tool will be used to identify and prioritize degraded wetlands for restoration, as well as minimally disturbed wetlands to conserve. Specific project objectives of Phase II were:

1) create a map showing the potential distribution of wetland and riparian habitats in Idaho;
2) improve Idaho's landscape-scale wetland assessment tool by creating a statewide raster-based landscape integrity model and then applying it to estimate wetland and riparian condition;
3) use site level rapid assessments of wetland condition to test the accuracy of landscape-scale assessment results;
4) disseminate a decision-support tool in the form of a GIS layers of wetland and riparian distribution, landscape integrity, and condition classification for statewide use;
5) demonstrate the tool's application in 5 case studies, including:

    - development of a wetland and riparian restoration strategy for the Boise and Payette River basins for a non-governmental conservation organization (partner Trout Unlimited);

- identification of important wetland and riparian resources to inform land-use planning in the Upper Salmon River basin (partner City of Stanley);
- prioritization of potential wetland protection and restoration sites in the Upper Snake River region which is undergoing urban development (partner Teton Regional Land Trust);
- condition assessment and distribution of springs in the Middle Snake River, Bruneau River, and Salmon Falls Creek basins, and vernal pool habitats in the Owyhee Uplands ecological section, for species of greatest conservation need to inform revision of the State Wildlife Action Plan (SWAP) (partner IDFG, Wildlife Diversity Program);
- a statewide conservation prioritization of wetland complexes based on assessment of condition, biodiversity values, and recreation, as part of the Statewide Comprehensive Outdoor Recreation and Tourism Plan (SCORTP) (partner Idaho Department of Parks and Recreation (IDPR).

Landscape-scale assessment can be used to map high levels of wetland disturbance and better target restoration activities. It can be a cost-effective way for governmental and non-governmental organizations to stretch limited assessment dollars. Landscape-scale assessment tools can be used by planners to address issues of wetland loss and identify potential conservation areas. It is an integrated approach that ensures the best use of data and resources. As a result of this project, wetland conservation, restoration, and mitigation activities can be conducted more efficiently and consistently across Idaho.

This report documents methods used to develop the landscape integrity model and condition classification. Results of the accuracy assessment are also included. Details of the 5 case studies are included in companion reports. This project should not be considered a complete assessment of wetland condition or a functional assessment. It is preliminary broad-scale assessment and has not been thoroughly ground-truthed. In addition, spatial layers for some important indicators of wetland condition (e.g., noxious weed distribution) were not available. Some layers used in the model may now be out of date. This was not a wetland mapping project, nor a delineation of jurisdictional wetlands.

STUDY AREAS

Figure 1 shows the regions analyzed for 5 landscape-scale assessment case studies. Detailed study area descriptions for each assessment area are included in the companion reports. Most analysis areas were determined by selecting subbasins (8-digit, 4th level hydrologic units) (e.g., HUC 8s) or subwatersheds (12-digit, 6th level HUC 12s) (Seaber et al. 1987) that encompassed the study areas of interest. The vernal pool analysis area for SWAP revision was equivalent to the Owyhee Uplands ecological section (Bailey 1980). The SCORTP prioritization occurred at the state level.

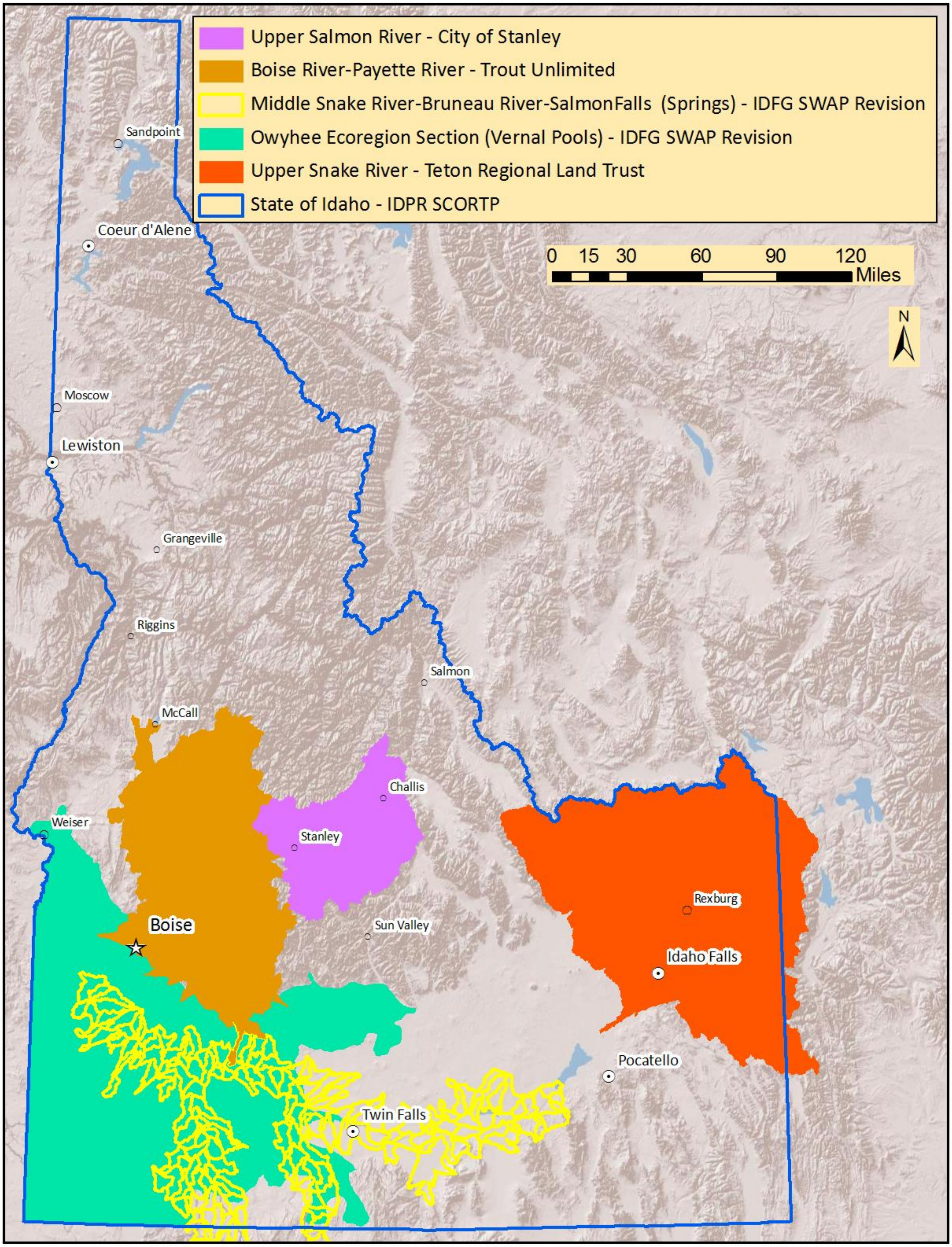

Figure 1. Areas analyzed in the 5 case studies.

METHODS

Map of potential wetland and riparian habitat distribution

Background: Idaho lacks accurate, current, and spatially comprehensive wetland maps. For example, NWI mapping is out of date, lacking in parts of east-central Idaho, and not completely digitized elsewhere in the state. Existing land cover maps of ecological systems are sometimes inaccurate or omit wetland and riparian stands too difficult to discern in remotely sensed images. Other spatial layers (e.g., hydrography) map only specific types of wetlands. To maximize its use and value, any landscape-scale wetland analysis requires a map of wetland distribution to which a condition can be estimated. The lack of a statewide map presented an obstacle to creating a landscape-scale wetland assessment tool for Idaho that had maximum applicability. To solve this problem we created a simple GIS model of potential wetland and riparian habitat distribution across Idaho. After comparing numerous spatial layers related to wetland and riparian habitats with the known distribution of these habitats, it was hypothesized that by stacking all relevant layers together a more complete distribution of wetland and riparian habitat could be estimated.

Spatial layers and sources: We acquired as many spatial layers representing wetland and riparian habitats as possible for Idaho. Spatial layer attributes and sources are listed below:

- ✓ flowlines (line, buffered by 30 m to represent riparian habitat; U. S. Geological Survey, National Hydrographic Dataset (NHD); http://nhd.usgs.gov/data.html)
- ✓ geothermal springs (point; Idaho Department of Water Resources (IDWR); http://www.idwr.idaho.gov/GeographicInfo/GISdata/gis_data.htm)
- ✓ hydric soils (polygon; Natural Resources Conservation Service; http://soils.usda.gov/)
- ✓ Idaho hydrography streams (line, buffered by 30 m to represent riparian habitat; Interactive Numeric and Spatial Information Data Engine for Idaho (INSIDE); http://inside.uidaho.edu/index.html)
- ✓ springs (point; Geographic Names Information System (GNIS) place names, INSIDE; http://inside.uidaho.edu/index.html)
- ✓ swamps (point; GNIS place names, INSIDE; http://inside.uidaho.edu/index.html)
- ✓ playas (polygon; NHD; http://nhd.usgs.gov/data.html)
- ✓ springs and seeps (polygon; NHD; http://nhd.usgs.gov/data.html)
- ✓ swamps and marshes (polygon; NHD; http://nhd.usgs.gov/data.html)
- ✓ water source delineations - springs (polygon; Idaho Department of Environmental Quality from INSIDE; http://inside.uidaho.edu/index.html)
- ✓ wetland and riparian ecological systems (raster; NatureServe 2005; available from IDFG)
- ✓ wetland and riparian ecological systems (raster; Northwest Gap Analysis Project Landcover (NW ReGAP) 2009; http://gap.uidaho.edu/index.php/gap-home/Northwest-GAP/landcover/)
- ✓ wetlands (polygons; National Wetlands Inventory (NWI); http://www.fws.gov/wetlands/Data/index.html)

Wetland and riparian ecological systems included in the model were:

- Boreal Depressional Bog
- Boreal Fen
- Columbia Basin Foothill Riparian Woodland and Shrubland
- Columbia Plateau Silver Sagebrush Seasonally Flooded Shrub-Steppe
- Columbia Plateau Vernal Pool
- Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland
- Inter-Mountain Basins Alkaline Closed Depression
- Inter-Mountain Basins Greasewood Flat
- Inter-Mountain Basins Interdunal Swale Wetland
- Inter-Mountain Basins Playa
- Inter-Mountain Basins Wash
- North American Arid West Emergent Marsh
- Northern Rocky Mountain Avalanche Chute Shrubland
- Northern Rocky Mountain Conifer Swamp
- Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland
- Northern Rocky Mountain Wooded Vernal Pool
- Rocky Mountain Alpine Dwarf-Shrubland
- Rocky Mountain Alpine-Montane Wet Meadow
- Rocky Mountain Lower Montane Riparian Woodland and Shrubland
- Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland
- Rocky Mountain Subalpine-Montane Fen
- Rocky Mountain Subalpine-Montane Mesic Meadow
- Rocky Mountain Subalpine-Montane Riparian Shrubland
- Rocky Mountain Subalpine-Montane Riparian Woodland

Any point, line, or polygon layers were converted to raster layers (30 m^2 pixels). The layers were assigned a unique value so the original source layers present could be later identified. With the exceptions of the NHD flowlines and Idaho hydrography streams layers, all input raster layers were combined into a single raster layer representing the potential occurrence of wetland and riparian habitats across Idaho. The two stream layers were kept as separate raster layers for maintaining the ability to easily include or drop them from future analyses.

After the model was built its accuracy was checked by comparing aerial imagery of known wetlands with predicted wetlands. The initial model tended to overestimate wetland habitat extent due to the inclusion of the "Inter-Mountain Basins Greasewood Flat", "Rocky Mountain Alpine Dwarf-Shrubland", and "Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland" ecological systems, each of which occurs in both upland and wetland settings. These systems were dropped from the final model. Certain hydric soils, as well as the source water delineation springs layer, also overestimated wetland extent and were dropped.

Landscape Integrity Model

Background: Landscape-scale wetland threat and impairment assessment has been widely applied, both at the national level (Faber-Langendoen et al. 2006, Comer and Hak 2012) and in various states, including Colorado (Lemly et al. 2011), Delaware and Maryland (Tiner 2002 and 2005; Weller et al. 2007), Minnesota (Sands 2002), Montana (Daumiller 2003, Vance 2009), North Dakota (Mita et al. 2007), Ohio (Fennessy et al. 2007), Pennsylvania (Brooks et al. 2002 and 2004; Hychka et al. 2007; Wardrop et al. 2007), and South Dakota (Troelstrup and Stueven 2007). Most of these landscape-scale analyses use a similar list of spatial layer inputs to calculate metrics for condition analyses. Some of these studies focused on watershed-level analyses or specific focal areas. The prior landscape-scale assessment project in Idaho (Murphy and Schmidt 2010) used spatial analysis of NWI polygons to estimate the relative condition of wetlands habitats in 2 parts of the state.

For our second attempt in Idaho, we chose to build a raster-based landscape integrity model analogous to those for Montana (Vance 2009), Colorado (Lemly et al. 2011), and nationally (Faber-Langendoen et al. 2006, Comer and Hak 2012). Our current project builds off many of these prior landscape-scale assessments which laid the necessary scientific groundwork. Numerous past projects used reference wetland approaches to determine which GIS calculated metrics best predict wetland condition (Hychka et al. 2007, Mita et al. 2007, Troelstrup and Stueven 2007, Wardrop et al. 2007, Weller et al. 2007, Vance 2009, Murphy and Schmidt 2010). This required that wetlands of known condition (based on field-generated assessment data) are placed along a human disturbance gradient. GIS calculated land use and stressor metrics are then tested for correlation with wetland condition and their ability to predict condition of reference wetlands. In Idaho, Murphy and Schmidt (2010) used a screening approach similar to Mita et al. (2007), Troelstrup and Stueven (2007), and Weller et al. (2007) to identify the best metrics for their model. Statistical analyses analogous to those used by Hychka et al. (2007), Mita et al. (2007), Troelstrup and Stueven (2007), Weller et al. (2007), and Vance (2009) were used. Murphy and Schmidt (2010) found that human land uses, including crop land, pasture, and livestock grazing, were significantly positively correlated and predictive of wetland degradation. Some land development types, such as local roads, canals and ditches, and groundwater wells were also predictive of wetland degradation. Urban land use, highways, and population density were also correlated, but not strong predictors.

Spatial layers and sources: For this project, we did not evaluate additional metrics for their power of predicting wetland condition. Instead, we used all of the same spatial layers (except livestock grazing and population density) that Murphy and Schmidt (2010) found significantly correlated with wetland condition. We also utilized numerous other layers identified by other researchers

(Fennessy et al. 2007, Hychka et al. 2007, Mita et al. 2007, Troelstrup and Stueven 2007, Wardrop et al. 2007, Weller et al. 2007, Vance 2009, Lemly et al. 2011, Comer and Hak 2012) as good predictors of wetland condition. Spatial layers had to have statewide coverage for inclusion. Several spatial layers were downloaded from the statewide geospatial data clearinghouse, the Interactive Numeric and Spatial Information Data Engine for Idaho (INSIDE) (http://inside.uidaho.edu/index.html), but most were obtained from various state or federal agencies, including:

- Interior Columbia Basin Ecosystem Management Project (ICBEMP) (http://www.icbemp.gov/)
- IDWR (http://www.idwr.idaho.gov/GeographicInfo/GISdata/gis_data.htm)
- National Land Cover Database (NLCD) (http://www.mrlc.gov/finddata.php)
- NW ReGAP (2009) (http://gap.uidaho.edu/index.php/landcover/)
- U. S. Census Bureau, Topologically Integrated Geographic Encoding and Referencing (TIGER) (http://www.census.gov/geo/maps-data/data/tiger.html)
- U. S. Environmental Protection Agency (EPA) (http://www.epa.gov/geospatial/)
- NHD (http://nhd.usgs.gov/data.html)

A complete list of spatial layers used in the landscape integrity model and sources of the GIS data is in Table 1. NW ReGAP landcover (2009) was the most current Idaho land use map and thus chosen for the model. It is based on imagery taken in ~ 2000 (+/-) compared to the 2001 NLCD map which was based on ~ 1996 imagery. Each input was snapped to a 30 m^2 raster layer.

Statewide layers were lacking, or incomplete, for some important potential condition indicators of wetland condition, including mine tailings, beaver (*Castor canadensis*) presence, herbicide or pesticide use, livestock grazing, noxious weed and non-native invasive plant species abundance, nutrient loading, off-highway vehicle use, recent energy development (e.g., wind turbines), and sediment accumulation. Murphy and Schmidt (2010) created a GIS model showing the likelihood of livestock grazing based on ICBEMP maps of active grazing allotment and the presence of grassland and pasture cover types. We chose not to use this model because there was no way to determine grazing intensity. For example, within an allotment open to livestock use, grazing intensity and potential impacts are highly spatially variable based on local management. The NW ReGAP (2009) pasture/hay cover type was the only representation of areas grazed by livestock (Table 1). We also used the NW ReGAP (2009) land cover map to represent areas of non-native plant species invasion. For non-native plant species invasion, land cover codes 8401 (Introduced Upland Vegetation - Treed), 8402 (Introduced Upland Vegetation - Shrub), 8404 Introduced Upland Vegetation - Annual Grassland), 8406 (Introduced Riparian and Wetland Vegetation), and 8407 (Introduced Upland Vegetation - Perennial Grassland and Forbland) were used (as in Comer and Hak 2012). However, NW ReGAP (2009) does not map fine-scale noxious or non-native weed populations which may have significant localized impacts on wetland site or riparian reach condition.

Table 1. Spatial layers used in the landscape integrity model indicating land uses and stressors from human activities.

Land Uses and Activities Affecting Wetland Condition and Function	Input Spatial Layer Description	Original Source and Spatial Layer Name	Data Type	Attributes Selected
Agriculture - haying and livestock pasture; seeded fields, no till	NWReGAP: Agriculture, Pasture/Hay	Northwest Gap Analysis Project Landcover (NWReGAP 2009)	grid	value: 1403
Agriculture - irrigated row-crop, tilled; dryland farming, tilled	NWReGAP: Agriculture, Cultivated Cropland	Northwest Gap Analysis Project Landcover (NWReGAP 2009)	grid	value: 1402
Dairy - feedlot / concentrated livestock operation	Dairies	Idaho Department of Water Resources (IDWR) dairies (2010)	point	
Impervious surfaces (i.e., roofs, pavement, excessive runoff)	NLCD: Impervious Surfaces	National Land Cover Database (NLCD) (2001)	grid	impervious surface 0 - 1%
	NLCD: Impervious Surfaces	National Land Cover Database (NLCD) (2001)	grid	impervious surface ≥1 - ≤10%
	NLCD: Impervious Surfaces	National Land Cover Database (NLCD) (2001)	grid	impervious surface >10 - ≤25%
	NLCD: Impervious Surfaces	National Land Cover Database (NLCD) (2001)	grid	impervious surface >25 - ≤40%
	NLCD: Impervious Surfaces	National Land Cover Database (NLCD) (2001)	grid	impervious surface >40%
Industrial pollution source (effluent or solid waste from intense production activity, such as manufacturing, assembly or processing of materials, oil refineries, auto shops, welding yards, airports, etc.); sewage treatment plants and lagoons; surface solid waste facilities (landfills and waste collection sites)	National Pollutant Discharge Elimination System (NPDES) Water Pollutant Point Sources, Permits	U. S. Environmental Protection Agency (EPA)	point	
	Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) - Toxics Release Inventory, Superfund Sites; ICBEMP - Point Source Pollution Sources	U. S. Environmental Protection Agency (EPA); Interior Columbia Basin Ecosystem Management Project (ICBEMP)	polygon	
	NPDES Water Pollutant Point Sources, Permits	U. S. Environmental Protection Agency (EPA)	point	
	NPDES Water Pollutant Point Sources, Permits; ICBEMP -Point Source Pollution Sources	U. S. Environmental Protection Agency (EPA); Interior Columbia Basin Ecosystem Management Project (ICBEMP)	point	
Mining of peat, coal, sand/gravel, phosphate, metals, etc.; oil / gas extraction	Mine Point Locations - Potential (Claims) and Active Mines	Idaho Geological Survey Database of Mines and Prospects of Idaho (2005) from INSIDE Idaho	point	
	NWReGAP: Quarries, Mines, Gravel Pits, and Oil Wells	Northwest Gap Analysis Project Landcover (NWReGAP 2009)	grid	value: 1301

Table 1 continued.

Land Uses and Activities Affecting Wetland Condition and Function	Input Spatial Layer Description	Original Source and Spatial Layer Name	Data Type	Attributes Selected
Noxious weeds / introduced upland or wetland vegetation - recently disturbed or modified woodland, shrubland, annual grassland, perennial grassland, or forbland	NWReGAP: Introduced Vegetation, Recently Disturbed or Modified Vegetation	Northwest Gap Analysis Project Landcover (NWReGAP 2009)	grid	values: 8401, 8402, 8404, 8406, 8407
Railroads - transportation – low-medium intensity	Railroads	U. S. Census Bureau, Topologically Integrated Geographic Encoding and Referencing (TIGER) 2000 (1:100,000)	line	fc_TIGER00_ Railroads
Recreational / open space – medium-intensity; includes grassy lawns in urban landscape and recreational lands such as playgrounds, sports fields, swimming beaches, developed campgrounds, urban parks, golf courses, etc. and associated trails and unpaved roads; human-created open water reservoirs, stock ponds, fishing ponds, duck ponds, etc.; water management infrastructure	BLM Recreation Sites; IDPR Boating Access Points	U. S. Bureau of Land Management (BLM); Idaho Department of Parks and Recreation (IDPR) from INSIDE Idaho	point	
	NWReGAP: Open Space	Northwest Gap Analysis Project Landcover (NWReGAP 2009)	grid	values: 1201
Residential and commercial development - single family – high density (>20 units/ha); multi-family residential; commercial; central business districts	NWReGAP: High Intensity Urban	Northwest Gap Analysis Project Landcover (NWReGAP 2009)	grid	values: 1204
Residential and commercial development - single family rural – low density (less than 1 unit / ha)	NWReGAP: Low Intensity Urban	Northwest Gap Analysis Project Landcover (NWReGAP 2009)	grid	values: 1202
Residential and commercial development - single or multi-family – medium-intensity (>1-20 units/ha)	NWReGAP: Medium Intensity Urban	Northwest Gap Analysis Project Landcover (NWReGAP 2009)	grid	values: 1203
Timber harvest - recent logging or tree removal with 50-75% of trees >50 cm dbh removed	NWReGAP: Harvested Forest/Timber	Northwest Gap Analysis Project Landcover (NWReGAP 2009)	grid	values: 8106, 8107, 8108

Table 1 continued.

Land Uses and Activities Affecting Wetland Condition and Function	Input Spatial Layer Description	Original Source and Spatial Layer Name	Data Type	Attributes Selected
Transportation – high intensity (includes highways (4 lanes or larger) and their shoulders - interstates	Roads - Interstate	U. S. Census Bureau, Topologically Integrated Geographic Encoding and Referencing (TIGER) 2000 (1:100,000)	line	fc_TIGER00_A1
Transportation – low-medium intensity (includes streets and highways (2-3 lane paved) and their shoulders) - federal and state	Roads - State and Federal Highways	U. S. Census Bureau, Topologically Integrated Geographic Encoding and Referencing (TIGER) 2000 (1:100,000)	line	fc_TIGER00_A2 and A3
Transportation – low-medium intensity (includes streets and highways (2-3 lane paved) and their shoulders); local roads (paved 2 lane) - county	Roads - County and Local Paved Streets	U. S. Census Bureau, Topologically Integrated Geographic Encoding and Referencing (TIGER) 2000 (1:100,000)	line	fc_TIGER00_A4
Unpaved roads (dirt, crushed or loose gravel, or sometimes paved, 2-track, 1-2 lane, local traffic, 4WD)	Roads - Local Unpaved Roads	U. S. Census Bureau, Topologically Integrated Geographic Encoding and Referencing (TIGER) 2000 (1:100,000)	line	fc_TIGER00_A5
Utilities - corridors with low-medium intensity impacts	ICBEMP - Utility Corridors	Interior Columbia Basin Ecosystem Management Project (ICBEMP)	line	
water management - canals, dams, diversions, dikes, levees, reservoirs, etc. and associated structures dedicated to water extraction and flow management	Canals	National Hydrographic Dataset (NHD) waterbody and flowline	line	NHD flowline type = canal, ditch (336)
	Dams	Idaho Department of Water Resources (IDWR) dams (2010)	point	
	Reservoirs - Reservoir Surface Area	NHD waterbody; Idaho Hydrography; Geographic Names Information System (GNIS) place names from Interactive Numeric and Spatial Information Data Engine (INSIDE) Idaho	grid	NHD waterbody type = reservoir; GNIS place name = reservoir
	Water Diversions - Water Rights, Points of Diversion	Idaho Department of Water Resources (IDWR) points of diversion (2010)	point	
	Wells	Idaho Department of Water Resources (IDWR) Wells (2010)	grid	

EPA	http://www.epa.gov/geospatial/
ICBEMP	http://www.icbemp.gov/
IDWR	http://www.idwr.idaho.gov/GeographicInfo/GISdata/gis_data.htm
INSIDE	http://inside.uidaho.edu/index.html
NHD	http://nhd.usgs.gov/data.html
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NWReGAP	http://gap.uidaho.edu/index.php/landcover/
TIGER	http://www.census.gov/geo/maps-data/data/tiger.html

Calculation of metrics for the landscape integrity model: Spatial analysis in GIS was used to calculate the presence of human land use and activity (i.e., stressor) metrics for every 30 m^2 pixel across Idaho. A single raster layer that indicated a disturbance value for that pixel was produced. This was accomplished by first calculating the distance from each human land use category, development type, or stressor for each pixel. We used an inverse weighted distance model based on the assumption that ecological condition will be poorer in areas of the landscape with the most cumulative human activities and disturbances (Faber-Langendoen et al. 2006, Vance 2009, Lemly et al. 2011, Comer and Hak 2012). Condition improves as you move toward least developed areas, typically in a predictable pattern ("distance-decay function"). Different land uses and stressors affect wetland condition in differing non-linear patterns, and their impacts can easily extend beyond 100 m (Vance 2009, Lemly et al. 2011, Comer and Hak 2012). In Idaho, we lacked data useful for calculating the distance-decay functions for land uses and stressors. For simplicity, we chose a conservative linear distance-decay function; land uses or stressors within 50 m were considered to have twice the impact than disturbances 50 - 100 m away (as in Vance 2009). For this model, land uses and stressors > 100 m away were assumed to have negligible impact.

Because not all land uses or stressors impact wetlands the same way, a weighting scheme for each land use or stressor was determined (as in Rocchio and Crawford 2009, Vance 2009, Comer and Hak 2012). We reviewed literature to identify potential weighting schemes. We decided to borrow weighting coefficients from Landscape Development Intensity (LDI) indices (Brown and Vivas 2005, Fennessy et al. 2007, Durkalec et al. 2009) and a hydrogeomorphic (HGM) assessment of functions of riverine floodplains in the Northern Rocky Mountains (Hauer et al. 2002) (Table 2). An LDI is a landscape-scale assessment based on mapped human development and land use. The metric used in an LDI is computed from all the non-renewable energy (i.e., emergy) per unit area per time required for the mapped development or land use (Brown and Vivas 2005). Examples include electricity, fuel, fertilizer, pesticides, and water. Landscapes dominated by energy-intensive activities and development, such as commercial and industrial land uses, have the highest LDI scores. LDI coefficients originate from normalized LDI scores and are broadly applied. The advantage of the LDI is its foundation of measurable attributes, rather than arbitrary scales developed by expert judgment. This approach is capable of predicting wetland condition when applied in landscape-scale assessments (Fennessy et al. 2007, Durkalec et al. 2009). Hauer et al. (2002) used a similar weighting scheme for land uses that has been applied in similar wetland assessments (Rocchio and Crawford 2009). Tables 2 and 3 list weights applied to each land use or stressor in our landscape integrity model.

The condition value for each pixel was then calculated based on all input rasters (Table 3). For example, the value for a pixel with a 2-lane highway and railroad within 50 m and a home and urban park between 50 and 100 m is calculated as follows:

Stressor	Weighting Coefficient	x Distance Factor	= Impact
• 2-lane highway =	7.81	2	15.62
• railroad =	7.81	2	+ 15.62
• single family home - low density =	6.91	1	+ 6.91
• recreation / open space - medium intensity =	4.38	1	+ 4.38
		Total Disturbance Value	**= 42.53**

The total disturbance value was then multiplied by 100 for the purpose of conversion to integer values for the final raster layer, resulting landscape integrity model values from 0 to 14,055.

Wetland and Riparian Condition Ranking

Pixels potentially supporting wetland and riparian habitat were extracted from the landscape integrity model layer using the layer of potential wetland and riparian habitat distribution. The disturbance value of each wetland and riparian pixel was then ranked relative to all others in Idaho using methods analogous to Stoddard et al. (2005), Fennessy et al. (2007), Mita et al. (2007), Troelstrup and Stueven (2007), and Lemly et al. (2011). The scale used was an arbitrary ranking based on expert judgment and non-quantitative examination of the disturbance value distribution. Any scale (or no scale) can be applied by users based on their assessment needs. Five condition categories were used based on the value range in the landscape integrity model:

1 = *minimally disturbed* (top 1% of wetlands, values 0 – 141); wetlands with absence or near absence of human disturbances; zero to few stressors present; land use almost completely not human-created; equivalent to reference condition; conservation priority;

2 = *lightly disturbed* (2 - 5%, values 142 – 703); wetland deviates from the minimally disturbed class based on existing landscape impacts; few stressors present; majority of land use is not human-created; these are the best wetlands in areas where some human impacts are present; ecosystem processes and functions are within natural ranges of variation found in the reference condition, but threats exist; usually reference condition; conservation priority;

3 = moderately disturbed (6 - 15%, values 704 – 2,108); several stressors present; land use roughly split between human-created and non-human-created; ecosystem processes and functions are impaired and somewhat outside the range of variation found in the reference condition, but are still intact; ecosystem processes are restorable; sometimes the best remaining wetlands in watersheds with many human impacts; conservation and/or restoration priority;

4 = *severely disturbed* (16 - 40%, values 2,109 – 5,625); numerous stressors present; land use is majority human-created; ecosystem processes and functions are severely altered or disrupted and outside the range of variation found in the reference condition; ecosystem processes are restorable, but may require large investments of energy and money to succeed; potential restoration priority;

Table 2. Weighting coefficients used in Idaho's landscape integrity model for each land use and stressor.

Land Use or Stressor	Proposed Idaho LDI Co-efficient	Sources							
		Brown and Vivas 2005		Fennessy et al.		Durkalec et al. 2009		Hauer et al. 2002	
		Florida	LDI	Ohio / NLCD 2001	LDI	Ohio	LDI	Northwest	Co-efficient
Natural area / land managed for native vegetation without livestock or recent timber harvest, including naturally formed open water in lakes, ponds, rivers, and streams	**1.00**	Natural land / open water	1.00					Natural area / land managed for native vegetation	1.00
Natural area / land managed for native vegetation without livestock or recent timber harvest, including naturally formed open water in lakes, ponds, rivers, and streams	1.05							Fallow with no history of grazing or other human use in past 10 yrs	1.05
Tree plantations with new tree growth >1 m tall; recent timber harvest, selective logging or tree removal with <50% of trees >50 cm dbh removed	1.58	Tree plantations / silviculture	1.58					Selective logging or tree removal (<50% of trees >50 cm dbh removed)	1.25
Recreational / open land – low intensity; natural vegetation in cities maintained as nature parks, and undeveloped land that may be occupied by natural vegetation in an agricultural or urban landscape; includes fishing access points, primitive campgrounds, Wildlife Management Areas, conservation / protected lands, and associated non-motorized trails	1.83	Recreational / open land – low intensity	1.83					Light recreation (low-use trail)	1.11
Rangeland managed for native vegetation with light or rotational livestock grazing (vegetation utilization is less than 50% and/or area minimally trampled)	2.02	Unimproved pastureland / rangeland (with livestock)	2.02	Shrub / scrub	2.02			Light grazing	1.11
Recreational / open land – low intensity; natural vegetation in cities maintained as nature parks, and undeveloped land that may be occupied by natural vegetation in an agricultural or urban landscape; includes fishing access points, primitive campgrounds, Wildlife Management Areas, conservation / protected lands, and associated non-motorized trails	**2.36**		2.36					Moderate recreation (high-use trail)	1.43
Improved pasture / low intensity ranching (enclosed livestock grazing or horse paddock)	2.88	Improved pasture (without livestock)	2.77			Pasture	2.99		
Recent timber harvest, logging or tree removal with 50-75% of trees >50 cm dbh removed	**3.16**	Tree plantations / silviculture	3.16					Logging or tree removal (50-75% of trees >50 cm dbh removed)	2.50
Rangeland managed for native vegetation with moderate to heavy or non-rotational livestock grazing (vegetation utilization is greater than 50% and/or area trampled)	3.28	Unimproved pastureland / rangeland (with livestock)	3.28					Moderate grazing	1.67
Recreational / open land – low intensity; natural vegetation in cities maintained as nature parks, and undeveloped land that may be occupied by natural vegetation in an agricultural or urban landscape; includes fishing access points, primitive campgrounds, Wildlife Management Areas, conservation / protected lands, and associated non-motorized trails	3.41		3.41					Heavy grazing by livestock / intense recreation (ATV use / camping / popular fishing spot, etc.)	3.33

Table 2 continued.

Land Use or Stressor	Proposed Idaho LDI Co-efficient	Brown and Vivas 2005	LDI	Fennessy et al. 2007	LDI	Durkalec et al. 2009	LDI	Hauer et al. 2002	Co-efficient
Rangeland managed for native vegetation with moderate to heavy or non-rotational livestock grazing (vegetation utilization is greater than 50% and/or area trampled)	3.41	Unimproved pastureland / rangeland (with livestock)	3.41					Heavy grazing by livestock	3.33
Improved pasture / low intensity ranching (enclosed livestock grazing or horse paddock)	3.43	Improved pasture – low intensity (with livestock)	3.41	Grassland / herbaceous	3.41				
Orchards	3.68	Citrus	3.68						
Haying (seeded fields, no till)	**3.74**	General agriculture	3.74	Pasture / hay	3.74			Hayed	2.00
Improved pasture / high intensity ranching (enclosed livestock grazing or horse paddock)	3.75	Improved pasture – high intensity (with livestock)	3.74						
Recreational / open space – medium-intensity; grassy lawns in urban landscape and recreational lands (e.g., playgrounds, sports fields, swimming beaches, developed campgrounds, urban parks, golf courses, etc.; associated motorized and non-motorized trails and unpaved roads; human-created open water in reservoirs, stock ponds, fishing ponds, duck ponds, etc.; water management (e.g., dams, diversions, dikes, levees, etc. and associated structures dedicated to water flow management)	**4.38**	Recreational / open space – medium intensity	4.38			Urban / recreational grasses	4.38	Unpaved roads (e.g., driveway, tractor trail) / mining	10.00
Intensive irrigated row-crop, tilled agriculture; Intensive dryland farming, tilled agriculture; water management (includes dams, diversions, dikes, levees, etc. and associated structures dedicated to water flow management)	**5.00**	Row crops	4.54	Cultivated crops	4.54	Crop	5.07	Agriculture (tilled crop production)	5.00
Single family rural residential–low density (less than 1 unit / ha)	**6.90**	Single family residential – low density	6.90						
Recreational / open land – high intensity; stadiums (not associated with institutions such as schools and universities) and racetracks (horse, dog, car)	**6.92**	Recreational / open land – high intensity	6.92	Developed, open space	6.92				
Feedlot / concentrated livestock operation; dairy	**7.00**	Agriculture – high intensity	7.00						
Single family residential – medium-intensity (>1-20 units/ha)	**7.47**	Single family residential – medium density	7.47	Developed, low intensity	7.47				
Single family residential – medium-intensity (>1-20 units/ha)	7.70	Mobile homes – medium density	7.70						
Single family residential – high density (>20 units/ha)	**7.77**	Single family residential – high density	7.55	Developed, medium intensity	7.55	Residential	7.99		

Table 2 continued.

Land Use or Stressor	Idaho LDI Co-efficient	Brown and Vivas 2005	LDI	Fennessy et al. 2007	LDI	Durkalec et al. 2009	LDI	Hauer et al. 2002	Co-efficient
Transportation – low-medium intensity (includes streets and highways (2-3 lane paved) and their shoulders); local road (paved, 1 or narrow 2 lane)	**7.81**	Transportation – low intensity	7.81						
Commercial – low-intensity (businesses have large warehouses and showrooms, sometimes patches of vegetation occur between buildings); nursery (business where the production of nursery grade vegetation occurs including greenhouses, outbuildings, sales lots)	8.00	Commercial – low intensity	8.00						
Institutional including schools, universities, religious, military, medical and professional facilities, and government buildings	8.07	Institutional	8.07						
Transportation – high intensity (includes highways (4 lanes or larger) and their shoulders, and roads associated with airports, railroad terminals, bus and truck terminals, port facilities, and auto parking facilities)	8.28	Transportation – high intensity	8.28						
Single family residential – high density (>20 units/ha)	8.29	Mobile homes – high density	8.29						
Industrial (intense production activity on a daily basis, e.g., manufacturing, assembly or processing of materials / products and associated buildings and grounds, oil refineries, auto body and mechanic shops, welding yards, airports); water supply plants, etc.; mining of peat, coal, sand/gravel, phosphate, metals, etc.; oil / gas extraction; sewage treatment plants and lagoons; solid waste (landfills and waste collection facilities)	**8.48**	Industrial	8.32	Barren land	8.32	Commercial / industrial / transportation	8.64		
Multi-family residential–low intensity (areas that are predominantly multi-family residential units such as condominiums and apartment buildings up to 2 stories)	8.66	Multi-family residential – low intensity	8.66						
Commercial – high-intensity (area is entirely commercial use and paved, e.g., shopping malls, construction yards, storage buildings, parking lots, hotels, convention centers, theme parks, etc.)	9.18	Commercial – high intensity	9.18					Paved roads / parking lots / domestic or commercially developed buildings / gravel pits	10.00
Multi-family residential – high intensity (areas that are predominantly multi-family residential units such as condominiums and apartment buildings with 3 or more stories)	9.19	Multi-family residential – high intensity	9.19						
Central business districts - low intensity (average of 2 stories)	9.42	Central business district – low intensity	9.42	Developed, high Intensity	9.42				
Central business districts - high intensity (average of more than 2 stories)	10.00	Central business district – high intensity	10.00						
bold = co-efficients used in Idaho Landscape Integrity Model									

Table 3. Descriptions of all inputs used to calculate develop Idaho's landscape integrity model.

Land Use or Stressor Description	Weighting Coefficient	Distance Factor	Input Layer Description	Input Raster
Area of impervious surface associated with various land use types (examples listed below)			**National Land Cover Database Impervious Surfaces**	***imperv***
Equivalent to natural area / land managed for native vegetation without livestock or recent timber harvest, including naturally formed open water in lakes, ponds, rivers, and streams	1.00	0	Impervious Surfaces <u><</u>1%	*imperv0*
Equivalent to recreational / open land – low intensity; natural vegetation in cities maintained as nature parks; undeveloped land in an agricultural or urban landscape, fishing access points, primitive campgrounds, Wildlife Management Areas, conservation lands, non-motorized trails	2.36	1	Impervious Surfaces >1% to 10%	*imperv_1to10*
Equivalent to recreational / open land – high intensity including stadiums (not associated with institutions such as schools and universities) and racetracks (horse, dog, car)	6.92	1	Impervious Surfaces >10% to 25%	*imperv_11to25*
Equivalent to single family residential–medium-intensity (>1-20 units/ha)	7.47	1	Impervious Surfaces >25% to 40%	*imperv_26to40*
Equivalent to single family residential–high density (>20 units/ha)	7.77	1	Impervious Surfaces >40%	*imperv_gt40*
Introduced upland or wetland vegetation - recently disturbed or modified woodland, shrubland, annual grassland, perennial grassland, or forbland			**Euclidean Distance (ED) to NWReGAP (8401, 8402, 8404, 8407): Introduced Vegetation, Recently Disturbed or Modified Vegetation**	*rgapintrED*
	2.36	2	ED to NWReGAP Introduced Vegetation 0 to 50 m	*rgapintrED0*
	2.36	1	ED to NWReGAP Introduced Vegetation >50 to 100 m	*rgapintrED50*
	2.36	0	ED to NWReGAP Introduced Vegetation >100 m	*rgapintrED100*
Recent timber harvest - logging or tree removal with 50-75% of trees >50 cm dbh removed			**Euclidean Distance to NWReGAP (8106, 8107, 8108): Harvested Forest/Timber**	*rgaptimed*
	3.16	2	ED to NWReGAP Harvested Forest 0 to 50 m	*rgaptimed0*
	3.16	1	ED to NWReGAP Harvested Forest >50 to 100 m	*rgaptimed050*
	3.16	0	ED to NWReGAP Harvested Forest >100 m	*rgaptimed0100*
Recreational / open space – medium-intensity; includes grassy lawns in urban landscape and recreational lands such as playgrounds, sports fields, swimming beaches, developed campgrounds, urban parks, golf courses, etc. and associated motorized and non-motorized trails and unpaved roads; human-created open water in reservoirs, stock ponds, fishing ponds, duck ponds, etc.; water management (e.g., dams, diversions, dikes, levees, etc. and associated structures for water flow management)			**Euclidean Distance to Recreation Sites (BLM and Idaho Parks and Recreation Recreation Site Layers)**	***recite_ED***
	4.38	2	ED to Recreation Sites 0 to 50 m	*recsite_ED0*
	4.38	1	ED to Recreation Sites >50 to 100 m	*recsite_ED50*
	4.38	0	ED to Recreation Sites >100 m	*recite_ED100*

Table 3 continued.

Land Use or Stressor Description	Weighting Coefficient	Distance Factor	Input Layer Description	Input Raster
Recreational / open space – medium-intensity; includes grassy lawns in urban landscape and recreational lands such as playgrounds, sports fields, swimming beaches, developed campgrounds, urban parks, golf courses, etc. and associated motorized and non-motorized trails and unpaved roads; human-created open water in reservoirs, stock ponds, fishing ponds, duck ponds, etc.; water management (e.g., dams, diversions, dikes, levees, etc. and associated structures for water flow management)			**Euclidean Distance to NWReGAP (1201): Open Space**	***rgapospred***
	4.38	2	ED to NWReGAP open space 0 to 50 m	*rgapospred0*
	4.38	1	ED to NWReGAP open space 50 to 100 m	*rgapospred50*
	4.38	0	ED to NWReGAP open space >100 m	*rgapospred100*
Haying - seeded fields, no till			**Euclidean Distance to NWReGAP (1403): Agriculture, Pasture/Hay**	***rgp1403ED***
	3.74	2	ED to NWReGAP (1403) Agriculture, Pasture/Hay 0 to 50 m	*rgp1403ED0*
	3.74	1	ED to NWReGAP (1403) Agriculture, Pasture/Hay >50 to 100 m	*rgp1403ED50*
	3.74	0	ED to NWReGAP (1403) Agriculture, Pasture/Hay >100 m	*rgp1403ED100*
Intensive agriculture - irrigated row-crop, tilled; dryland farming, tilled			**Euclidean Distance to NWReGAP (1402): Agriculture, Cultivated Cropland**	***rgp1402_ED***
	5.00	2	ED to NWReGAP (1402) Agriculture, Cultivated Cropland 0 to 50 m	*rgp1402_ED0*
	5.00	1	ED to NWReGAP (1402) Agriculture, Cultivated Cropland >50 to 100 m	*rgp1402_ED50*
	5.00	0	ED to NWReGAP (1402) Agriculture, Cultivated Cropland >100 m	*rgp1402_ED100*
Dairy - feedlot / concentrated livestock operation			**Euclidean Distance to Dairies**	***dairy_ED***
	7.00	2	ED to Dairies 0 to 50 m	*dairy_0*
	7.00	1	ED to Dairies >50 to 100 m	*dairy_50*
	7.00	0	ED to Dairies >100 m	*dairy_100*
Canals - water management (includes dams, diversions, dikes, levees, etc. and associated structures dedicated to water flow management)			**Euclidean Distance to Canals**	***canal_ED***
	4.38	2	ED to Canals 0 to 50 m	*canal_ED0*
	4.38	1	ED to Canals >50 to 100 m	*canal_ED50*
	4.38	0	ED to Canals >100 m	*canal_ED100*
Dams - water management (includes dams, diversions, dikes, levees, etc. and associated structures dedicated to water flow management)			**Euclidean Distance to Dams**	***dam_ED***
	4.38	2	ED to Dams 0 to 50 m	*dam_ED0*
	4.38	1	ED to Dams >50 to 100 m	*dam_ED50*
	4.38	0	ED to Dams >100 m	*dam_ED100*
Reservoirs - water management (includes dams, diversions, dikes, levees, etc. and associated structures dedicated to water flow management)			**Euclidean Distance to Reservoir Surface Area**	***r_reservED***
	4.38	2	ED to Reservoirs 0 to 50 m	*r_reserv0*
	4.38	1	ED to Reservoirs >50 to 100m	*r_reserv50*
	4.38	0	ED to Reservoirs >100 m	*r_reserv100*

Table 3 continued.

Land Use or Stressor Description	Coefficient	Distance	Input Layer Description	Input Raster
Water diversions - water management (includes dams, diversions, dikes, levees, etc. and associated structures for water flow management)			**Euclidean Distance to Water Diversions**	***WRdvrs_ED***
	4.38	2	ED to Water Diversions 0 to 50 m	*WRdvrs_ED0*
	4.38	1	ED to Water Diversions >50 to 100 m	*WRdvrs_ED50*
	4.38	0	ED to Water Diversions >100 m	*WRdvrs_ED100*
Wells - water management (associated structures dedicated to water management)			**Euclidean Distance to Wells**	***wells_ED***
	4.38	2	ED to Wells <=50m	*wells_ED_0*
	4.38	1	ED to Wells >50 to 100 m	*wells_ED_50*
	4.38	0	ED to Wells >100 m	*wells_ED_100*
Industrial pollution source (waste from intense production activity, such as manufacturing, assembly or processing of materials, oil refineries, auto body and mechanic shops, welding yards, airports, etc.); sewage treatment plants and lagoons; surface solid waste facilities (landfills and waste collection sites)			**Euclidean Distance to CERCLA - Superfund Sites**	***Cercla_ED***
	8.48	2	ED to CERCLA - Superfund Sites 0 to 50 m	*Cercla_ED0*
	8.48	1	ED to CERCLA - Superfund Sites >50 to 100 m	*Cercla_ED50*
	8.48	0	ED to CERCLA - Superfund Sites >100 m	*Cercla_ED100*
Industrial pollution source (waste from intense production activity, such as manufacturing, assembly or processing of materials, oil refineries, auto body and mechanic shops, welding yards, airports, etc.); sewage treatment plants and lagoons; surface solid waste facilities (landfills and waste collection sites)			**Euclidean Distance to NPDES - Water Pollutant Point Sources**	***NPDES_ED***
	8.48	2	ED to NPDES - Water Pollutant Sources 0 to 50 m	*NPDES_ED0*
	8.48	1	ED to NPDES - Water Pollutant Sources >50 to 100 m	*NPDES_ED50*
	8.48	0	ED to NPDES - Water Pollutant Sources >100 m	*NPDES_ED100*
Mines - industrial (intense production activity on a daily basis); mining of peat, coal, sand/gravel, phosphate, metals, etc.; oil / gas extraction			**Euclidean Distance to Mine Point Locations - Potential (Claims) and Active Mines**	***mine_ED***
	8.48	2	ED to Mines 0 to 50 m	*mine_ED0*
	8.48	1	ED to Mines >50 to 100 m	*mine_ED50*
	8.48	0	ED to Mines >100 m	*mine_ED100*
Mines - industrial (intense production activity on a daily basis); mining of peat, coal, sand/gravel, phosphate, metals, etc.; oil / gas extraction			**Euclidean Distance to NWReGAP (1301): Quarries, Mines, Gravel Pits, and Oil Wells**	***regapmined***
	8.48	2	ED to NWReGAP (1301) Mining 0 to 50 m	*regapmined0*
	8.48	1	ED to NWReGAP (1301) Mining >50 to 100 m	*regapmined50*
	8.48	0	ED to NWReGAP (1301) Mining >100 m	*regapmined100*
Single family residential – high density (>20 units/ha); multi-family residential; commercial; central business districts			**Euclidean Distance to NWReGAP (1204): High Intensity Urban**	***regapHinte***
	7.77	2	ED to NWReGAP (1204) High Intensity Urban 0 to 50 m	*regapHinte0*
	7.77	1	ED to NWReGAP (1204) High Intensity Urban >50 to 100 m	*regapHint5e0*
	7.77	0	ED to NWReGAP (1204) High Intensity Urban >100 m	*regapHinte100*

Table 3 continued.

Land Use or Stressor Description	Weighting Coefficient	Distance Factor	Input Layer Description	Input Raster
Single or multi-family residential – medium-intensity (>1-20 units/ha)			**Euclidean Distance to NWReGAP (1203): Medium Intensity Urban**	***rgapmined***
	7.47	2	ED to NWReGAP (1203) Medium Intensity Urban 0 to 50 m	*rgapmined0*
	7.47	1	ED to NWReGAP (1203) Medium Intensity Urban >50 to 100 m	*rgapmined50*
	7.47	0	ED to NWReGAP (1203) Medium Intensity Urban >100 m	*rgapmined100*
Single family rural residential – low density (less than 1 unit / ha)			**Euclidean Distance to NWReGAP (1202): Low Intensity Urban**	***rgaplwined***
	6.90	2	ED to NWReGAP (1202) Low Intensity Urban 0 to 50 m	*rgaplwined0*
	6.90	1	ED to NWReGAP (1202) Low Intensity Urban 50 to 100 m	*rgaplwined50*
	6.90	0	ED to NWReGAP (1202) Low Intensity Urban >100 m	*rgaplwined100*
Transportation – high intensity (includes highways (4 lanes or larger) and their shoulders			**Euclidean Distance to Roads - Interstate (A1)**	***RdsA1_ED***
	8.28	2	ED to Roads - Interstate (A1) 0 to 50 m	*RdsA1_ED0*
	8.28	1	ED to Roads - Interstate (A1) >50 to 100 m	*RdsA1_ED50*
	8.28	0	ED to Roads - Interstate (A1) >100 m	*RdsA1_ED100*
Transportation – low-medium intensity (includes streets and highways (2-3 lane paved) and their shoulders)			**Euclidean Distance to Roads - State and Federal Highways (A2 and A3)**	***RdsA23_ED***
	7.81	2	ED to Roads - State and Federal Highways (A2 and A3) 0 to 50 m	*RdsA23_ED0*
	7.81	1	ED to Roads - State and Federal Highways (A2 and A3) >50 to 100 m	*RdsA23_ED50*
	7.81	0	ED to Roads - State and Federal Highways (A2 and A3) >100	*RdsA23_ED100*
Transportation – low-medium intensity (includes streets and highways (2-3 lane paved) and their shoulders); local roads (paved 2 lane)			**Euclidean Distance to Roads - County (A4)**	***RdsA4_ED***
	7.81	2	ED to Roads - County (A4) 0 to 50 m	*RdsA4_ED0*
	7.81	1	ED to Roads - County (A4) >50 to 100 m	*RdsA4_ED50*
	7.81	0	ED to Roads - County (A4) >100 m	*RdsA4_ED100*
Unpaved roads (dirt, crushed or loose gravel, or sometimes paved, 2-track, 1-2 lane, local traffic)			**Euclidean Distance to Roads - Local (A5)**	***RdsA5_ED***
	4.38	2	ED to Roads - Local (A5) 0 to 50 m	*RdsA5_ED0*
	4.38	1	ED to Roads - Local (A5) >50 m to 100 m	*RdsA5_ED50*
	4.38	0	ED to Roads - Local (A5) >100 m	*RdsA5_ED100*
Railroads - transportation – low-medium intensity			**Euclidean Distance to Railroads**	***rail_ED***
	7.81	2	ED to Railroads ED 0 to 50	*rail_ED0*
	7.81	1	ED to Railroads >50 to 100	*rail_ED50*
	7.81	0	ED to Railroads >100	*rail_ED100*
Utilities - corridors with low-medium intensity impacts			**Euclidean Distance to Interior Columbia Basin Ecosystem Management Project Utilities**	***icbputl_ed***
	7.81	2	ED to ICBEMP Utilities 0 to 50 m	*icbputl_ed0*
	7.81	1	ED to ICBEMP Utilities >50 to 100 m	*icbputl_ed50*
	7.81	0	ED to ICBEMP Utilities >100 m	*icbputl_ed100*

5 = *completely disturbed* (bottom 41 - 100%, values 5,626 – 14,055); many stressors present; land use is nearly completely human-created; ecosystem processes and functions are disrupted and outside the range of variation in the reference condition; ecosystem processes are very difficult or not feasible to restore.

Accuracy Assessment

Field-generated rapidly assessed condition data was used to check the accuracy of wetland and riparian condition predicted by the landscape-scale wetland assessment tool. During the project (2008 - 2011) we collected rapid assessment data at 132 reference wetlands, representing several concurrent wetland projects (Figure 2; Appendix 1). Field-estimated condition of 9 additional wetlands assessed in 2006 was used to supplement our dataset. Of these reference wetlands, 76 occurred within the case study areas shown in Figure 1 (Figure 2). Although most wetlands were not randomly located, assessed wetlands were mostly representative of the diversity of wetland types and environmental settings found in the case study areas and Idaho's ecological regions (Figure 3). They also represented a broad range of observed ecological condition (Appendix 1).

Rapidly assessed wetland and riparian condition data originated from several field projects (Appendix 1). Primary data sources were randomly selected wetlands from the Landscape-scale Wetland Assessment Tool - Phase I project (Panhandle and Lower Snake River Plain regions) (Murphy and Schmidt 2010) and wetlands assessed during the current project (Phase II) (Mores-Grimes Creek, Stanley, Teton Basin). Additional assessments from across the state conducted for the "Assessment of Restored, Enhanced, and Created Wetlands" project (also an EPA WPDG; Murphy and Weekly 2012) were also used. These projects all used the "Idaho Wetland Condition Rapid Assessment Method" based on checklists of observable land uses and stressors (Murphy and Schmidt 2010). An earlier version of this checklist method was used to assess wetland sites in the Middle and South Fork Clearwater River basins in 2006 (IDFG 2007). Results from these sites were also included in the reference wetland dataset. We also used condition data from the 2011 National Wetland Condition Assessment and companion Idaho Wetland Condition Assessment. These projects used a different method for estimating condition (USA Rapid Assessment Method; US EPA 2011), the results of which were scaled to be comparable to the Idaho method.

The correlation between field rapid assessment condition and landscape integrity model predicted condition was examined for each reference wetland / riparian site. Before Pearson product moment correlation was performed in an R package (Wessa 2013), normality of the landscape intregrity model data was improved by a square root transformation. The relationship between field assessment and landscape integrity model condition was examined with simple linear regression using the least squares method (Wessa 2013). Rapidly assessed condition data from each reference site were also ranked using the same methods and condition categories (1 to 5) used for wetland and riparian pixels in the landscape integrity model.

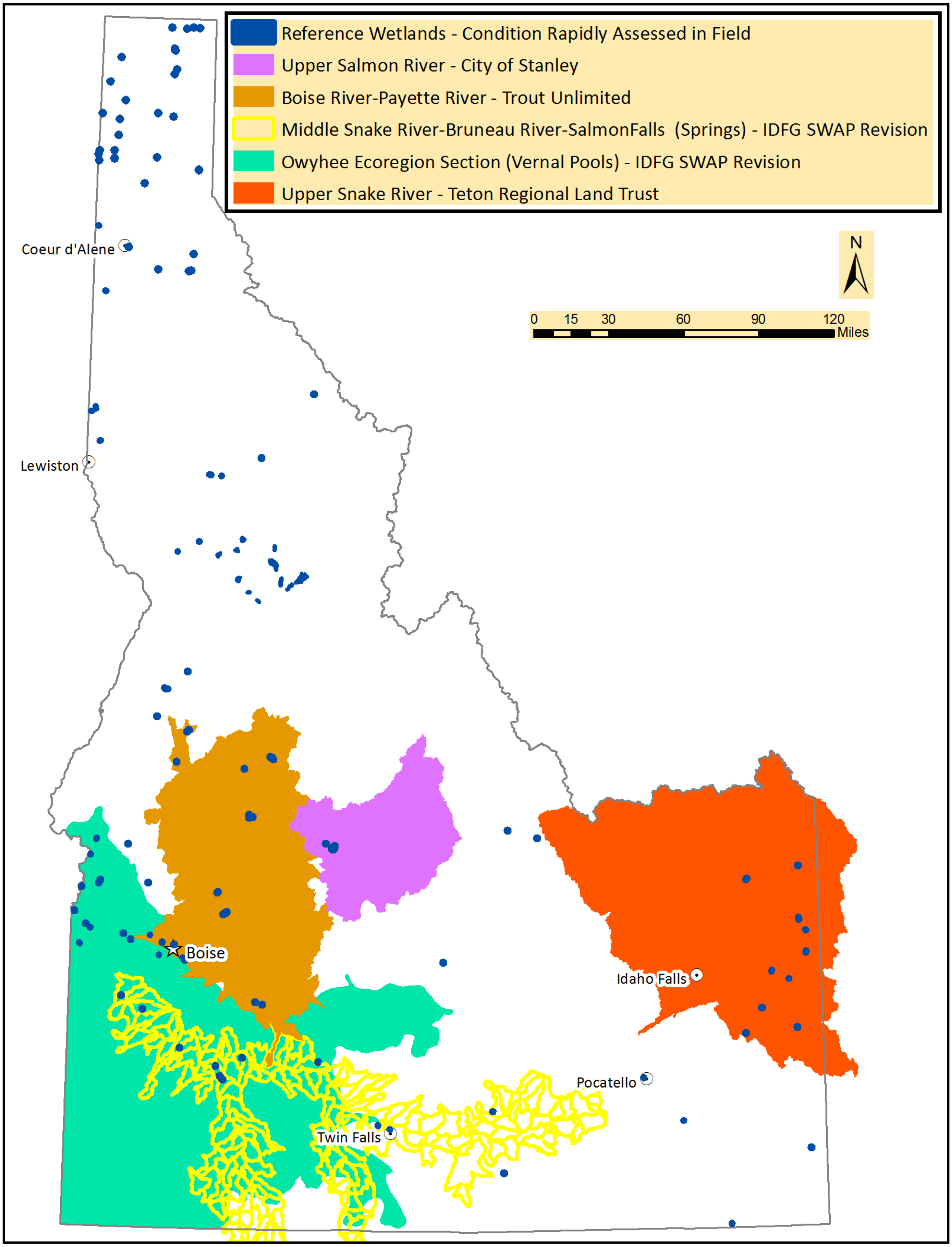


Figure 2. Locations of reference wetlands rapidly assessed in the field for ecological condition.

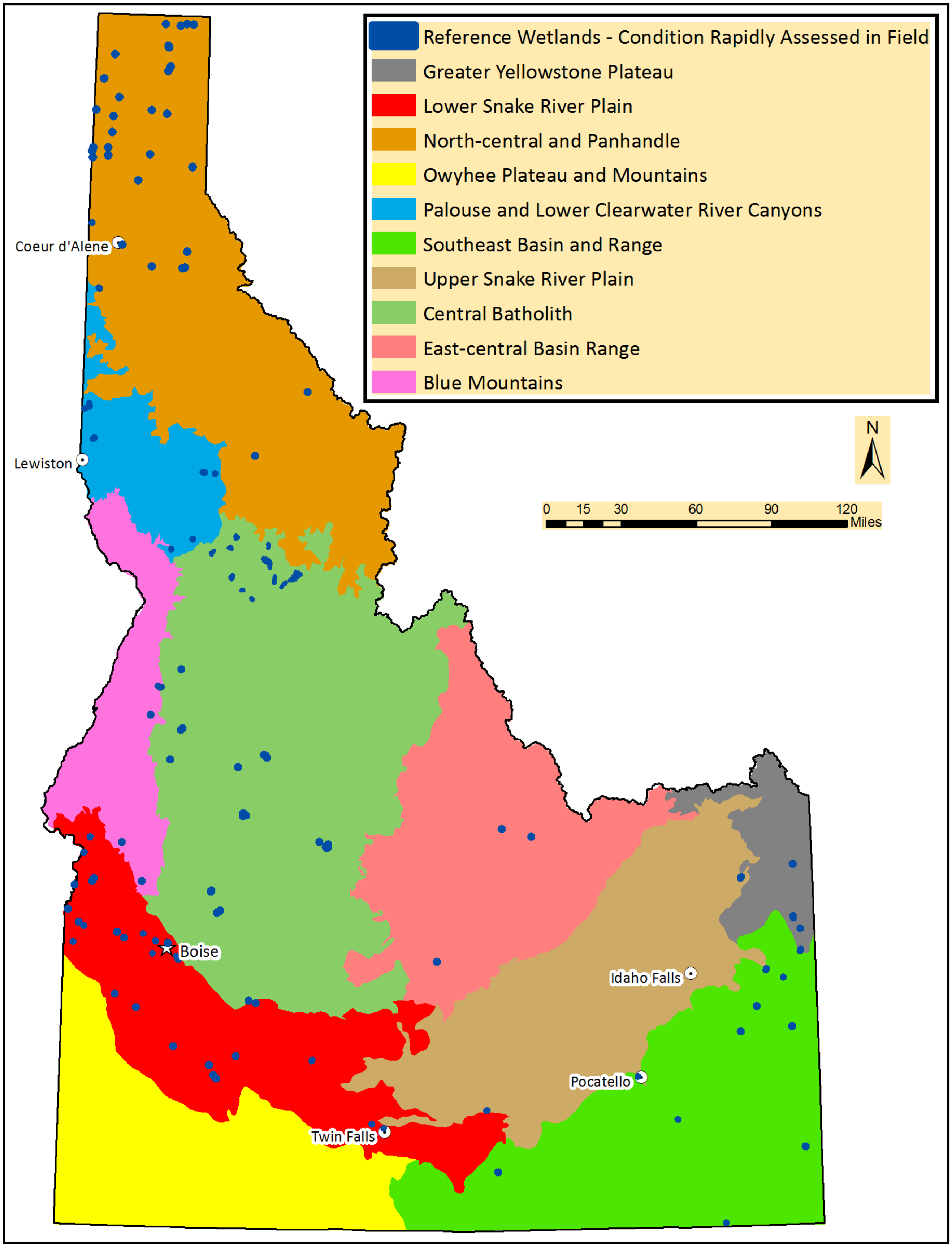


Figure 3. Locations of reference wetlands relative to Idaho's ecological regions.

RESULTS AND DISCUSSION

Map of potential wetland and riparian habitat distribution

Figure 4 shows the potential distribution of wetland and riparian habitats as predicted by our model. A qualitative accuracy assessment indicated that the final model correctly predicted wetland presence approximately 80% of the time. This exceeded our expectations and the resulting map is useful. Inclusion of the "Rocky Mountain Subalpine-Montane Mesic Meadow" ecological system in the model resulted in an overestimation of wetlands, especially on drier subalpine mountain slopes. However, it was important to keep this system in the model because many meadow sites known to include wetlands were also mapped as this type. The extent of actual wetland and riparian habitats was also overestimated on the Snake River Plain and Owyhee Front portion of the Snake River valley. This was due to the inclusion of intermittently flowing arroyos in the estimation of riparian habitats, as well as over-mapping of alkaline wetlands.

The map should not be used to determine the actual boundaries of wetlands, but it can be used as a guide to predicting where wetland and riparian habitats are most likely to occur. It is important to note that this model has been ground-truthed in only small areas of the state and not for all types of wetland and riparian habitats.

Landscape Integrity Model

We successfully produced a landscape integrity model for the entire state of Idaho. This layer, shown in Figure 5, can be used to assess both upland and wetland habitats. As expected, urban areas and highway corridors were the most highly disturbed areas, followed by agricultural lands. Lands managed for timber tended to be lightly to moderately disturbed, depending on road density and the amount of mapped recent harvest. Rangelands tended to be minimally to lightly disturbed, also depending on road density and cover of non-native plant species. Localized grazing impacts were likely poorly expressed in our model.

Figure 6 shows the landscape integrity model filtered down to just wetlands and riparian areas predicted by our model of potential wetland and riparian habitats. Wetlands in major river valleys with concentrated development (e.g., lower Boise and Payette Rivers, Kootenai River, Wood River, and Henry's Fork River) and intensive agricultural areas (e.g., Mud Lake) clearly have the highest disturbance levels.

Wetland and Riparian Condition Ranking

Figure 7 shows wetland and riparian condition ranked in 5 categories. The same patterns in Figure 6 are evident, but the extent of moderately to completely disturbed wetlands on the Snake River Plain and in other agricultural or urbanized valleys is more clearly shown. Figures 8 - 20 show the same wetland and riparian condition results, but at a regional scale for better viewing. In the Panhandle of north Idaho (Figure 8), wetland disturbance is highest in the Highway 95 corridor. As expected, high condition conservation wetlands occur in the Upper Priest River valley. In North-central Idaho (Figure 9), extensive wetlands in the Coeur d'Alene River valley are shown as undisturbed because accumulation of toxic sediments (a legacy of upstream mining) is not included in the landscape integrity model. Figures 11 and 13 highlight the importance of both conservation and restoration in Long Valley (McCall and Cascade areas) where extensive wetlands of mixed condition are present. Similar patterns occur in East-central basins (Figure 15), the Greater Yellowstone Plateau (e.g., Henry's Fork River and Teton Basin) (Figure 16), Fort Hall Bottoms on the Snake River near Pocatello (Figure 19), and southeast valleys (e.g., Malad River, where disturbed alkaline wetlands occur, and upper Portneuf River) (Figure 20). These broad alluvial valleys are rich with spring-fed wetlands and riverine floodplains. These valleys also have numerous ranches with haying and livestock pasturing, reflecting the abundance of water and fertile soils. Vernal pools and playas on the Owyhee Plateau are minimally to lightly disturbed and of high conservation priority (Figure 17). Extensive, high condition, conservation priority wetlands also occur in the cold, high valleys of southeast Idaho, especially in the upper Blackfoot River and Bear Lake basin (Figure 20) where agricultural use is limited by a short growing season.

Accuracy Assessment

The landscape integrity model generally performed well in its ability to predict wetland / riparian condition at reference sites. Field rapid assessment condition values and landscape integrity model values (transformed by square root to improve normality, skewness = 0.103, kurtosis = -0.114) were moderately well correlated (R^2 = 0.21, 101 df) (see chart below), but this relationship was highly significant (t = 5.23, p <0.001).

Results of GIS landscape-scale assessment were also verified by comparing the predicted ecological condition of wetlands determined in the field using rapid assessment methods (Figure 2; Appendix 1). Statewide, the landscape assessment matched the rapidly field-assessed condition 63% of the time. Thirty percent of the sites were misclassified by one condition class and 7% misclassified by two condition classes.

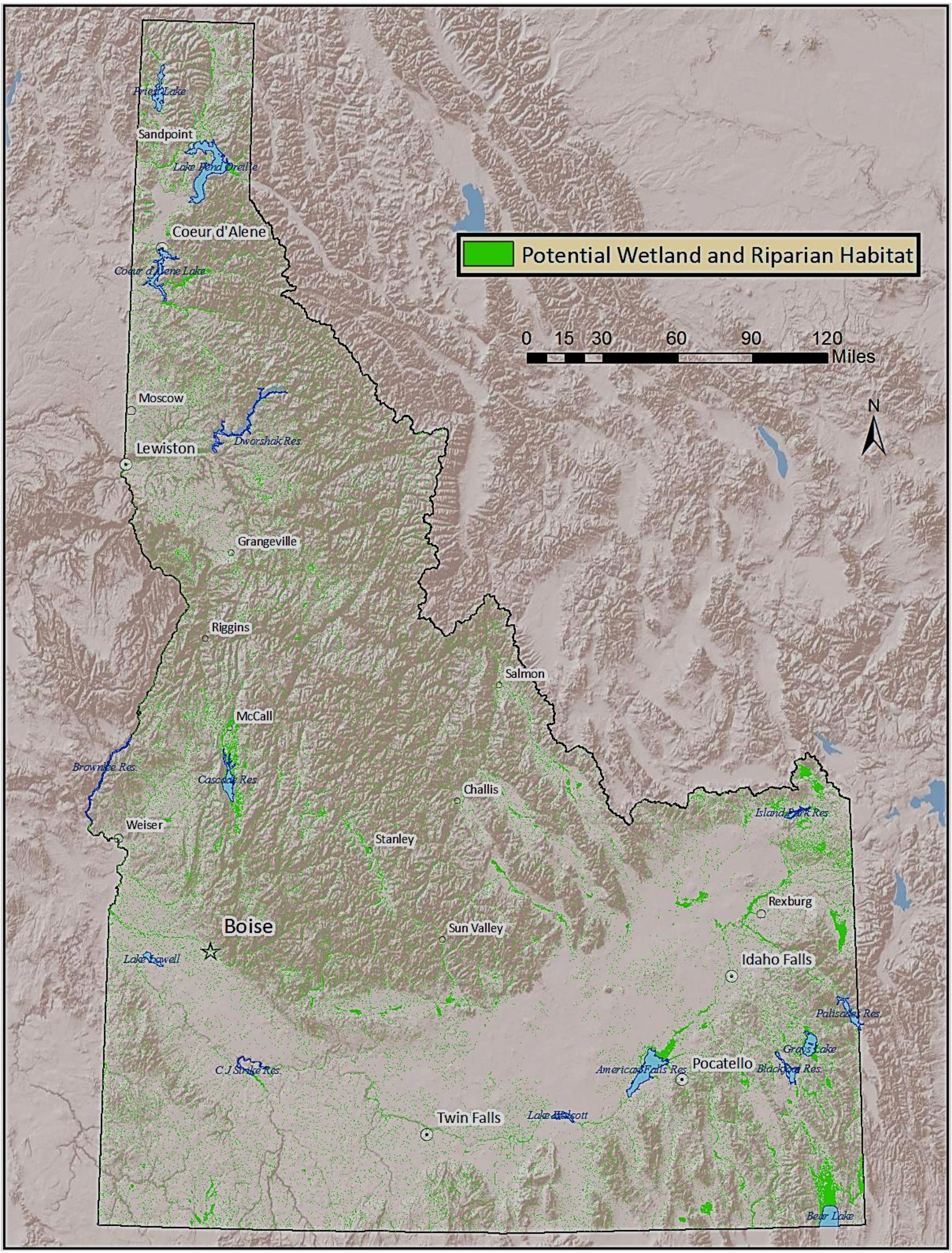


Figure 4. Distribution of potential wetland and riparian habitat.

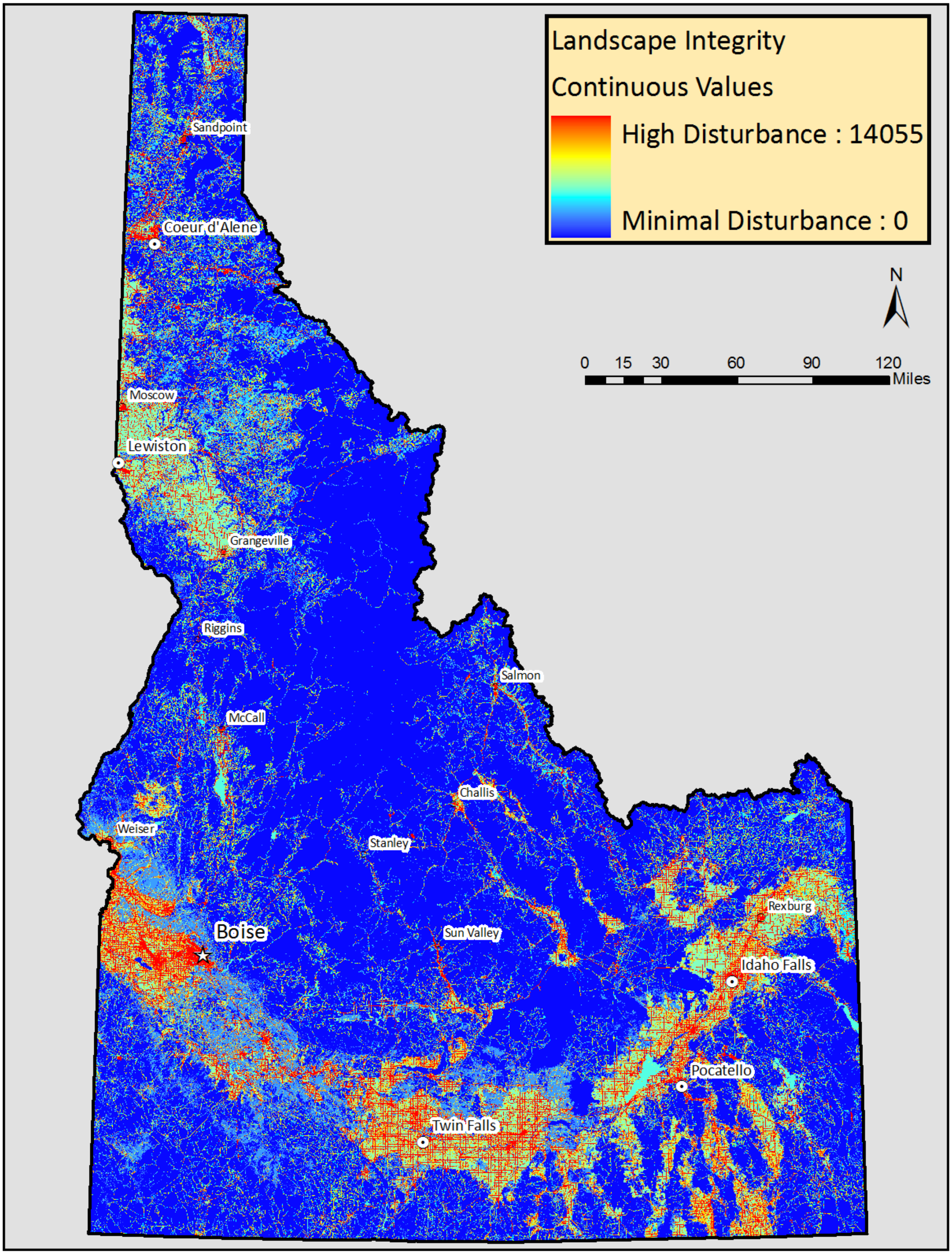
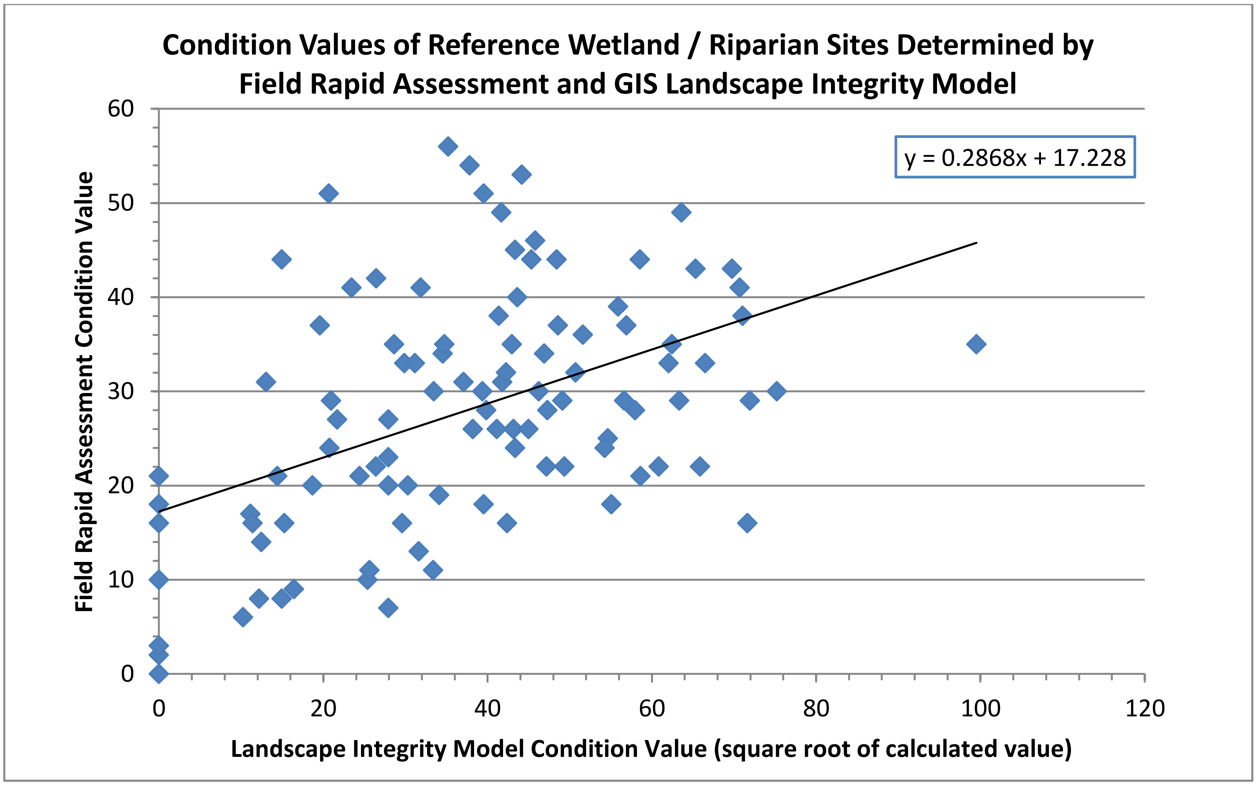


Figure 5. Landscape integrity model results.



Of the case studies, the landscape-scale wetland assessment tool performed best in the Boise and Payette River basins (see following list) where the primary wetland and riparian stressors were related to roads, a relatively well-mapped land use. The assessment tool also performed well in other mountainous regions of the state, including the Blue Mountains and Central Batholith, likely for the same reasons. This result is comparable to Vance (2009) in Montana. In contrast, the model did not predict wetland condition very well at the town of Stanley, in the Upper Salmon River basin, nor on the Snake River Plain. At Stanley, this may be due to the fact that observed cattle grazing and localized human impacts (e.g., trampling) are inadequately mapped at a broader spatial scale. On the Snake River Plain, cattle grazing and non-native species invasion (e.g., cheatgrass) were commonly observed but difficult to detect with land use and stressor layers used in the model. Similar factors likely influenced performance of the model in the Palouse and Lower Clearwater River Canyons region.

Case Study / Ecological Region	% Correctly Predicted
• Blue Mountains Ecological Region (n = 4)	75
• Boise River-Payette River – Trout Unlimited (n = 27)	70
• Central Batholith Ecological Region (n = 10)	90
• East-central Basin and Range Ecological Region (n = 3)	100
• Middle Snake River-Bruneau River-SalmonFalls (Springs) – IDFG SWAP (n = 14)	64
• North-central and Panhandle Ecological Region (n = 33)	58
• Owyhee Ecoregion Section (Vernal Pools) – IDFG SWAP (n = 13)	62

• Palouse and Lower Clearwater River Canyons Ecological Region (n = 9)	44
• Southeast Basin and Range Ecological Section (n = 5)	80
• Upper Salmon River – City of Stanley (n = 12)	42
• Upper Snake River – Teton Regional Land Trust (n = 11)	55

The landscape-scale wetland assessment tool was best at predicting the condition of minimally and severely disturbed wetlands (see following list). This is intuitive because in areas with few human impacts it is easy (either as a field observer or GIS model) to recognize human land uses and detect stressors (or lack thereof) against a backdrop of natural vegetation and hydrology. Similarly, in areas with high levels of human impacts (e.g., severely disturbed wetlands) an observer or model is likely to tally the many human land uses and stressors present. Intermediate condition classes (e.g., lightly and moderately) represent a gradation of human impacts where an observer or model may have greater difficulty properly classifying the influence of stressors.

Wetland Condition Class	**% Correctly Predicted**
• minimally (n = 42)	79
• lightly (n = 41)	44
• moderately (n = 35)	63
• severely (n = 21)	76
• completely (n = 2)	0

Overall, our results were similar to an accuracy assessment of landscape scale assessment in North Dakota (Mita et al. 2007). Our landscape-scale assessment tool out-performed landscape integrity models produced in Colorado (approximately 53% correct prediction) (Lemly et al. 2011) and Montana (51 - 56% correct prediction) (Vance 2009). When sites classified correctly and those only off by one condition class were combined (93% of our samples), our results were similar to Colorado (approximately 88% correct) and exceeded Montana (approximately 74%) (Vance 2009). This suggests that reducing the number of wetland condition classes from five to four, or three, would increase predictive precision. The model of landscape integrity performed much better than the initial Phase I prototype model produced for Idaho by Murphy and Schmidt (2010) which correctly predicted condition at only 48% of rapidly assessed wetlands.

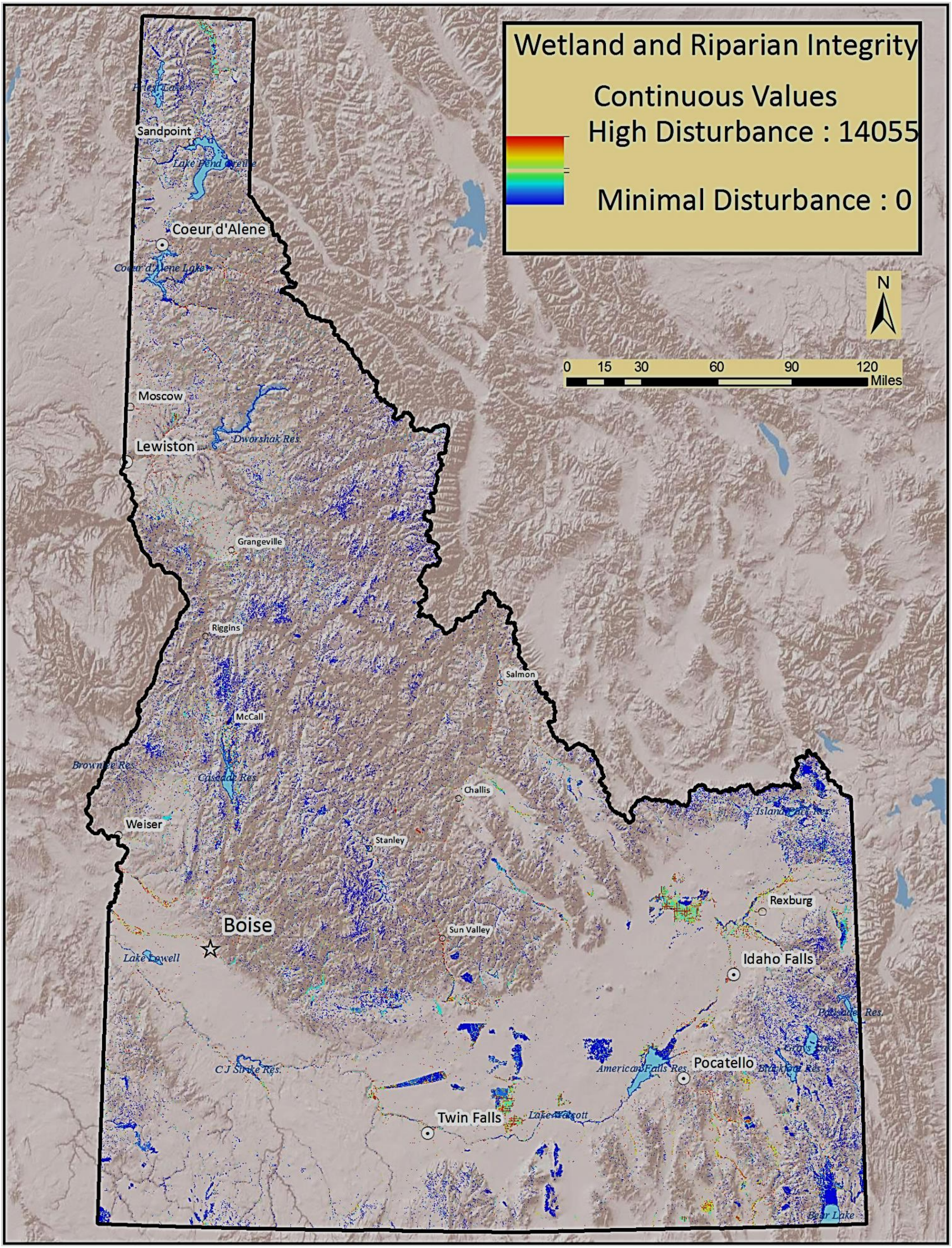


Figure 6. Landscape integrity model filtered to potential wetland and riparian habitat.

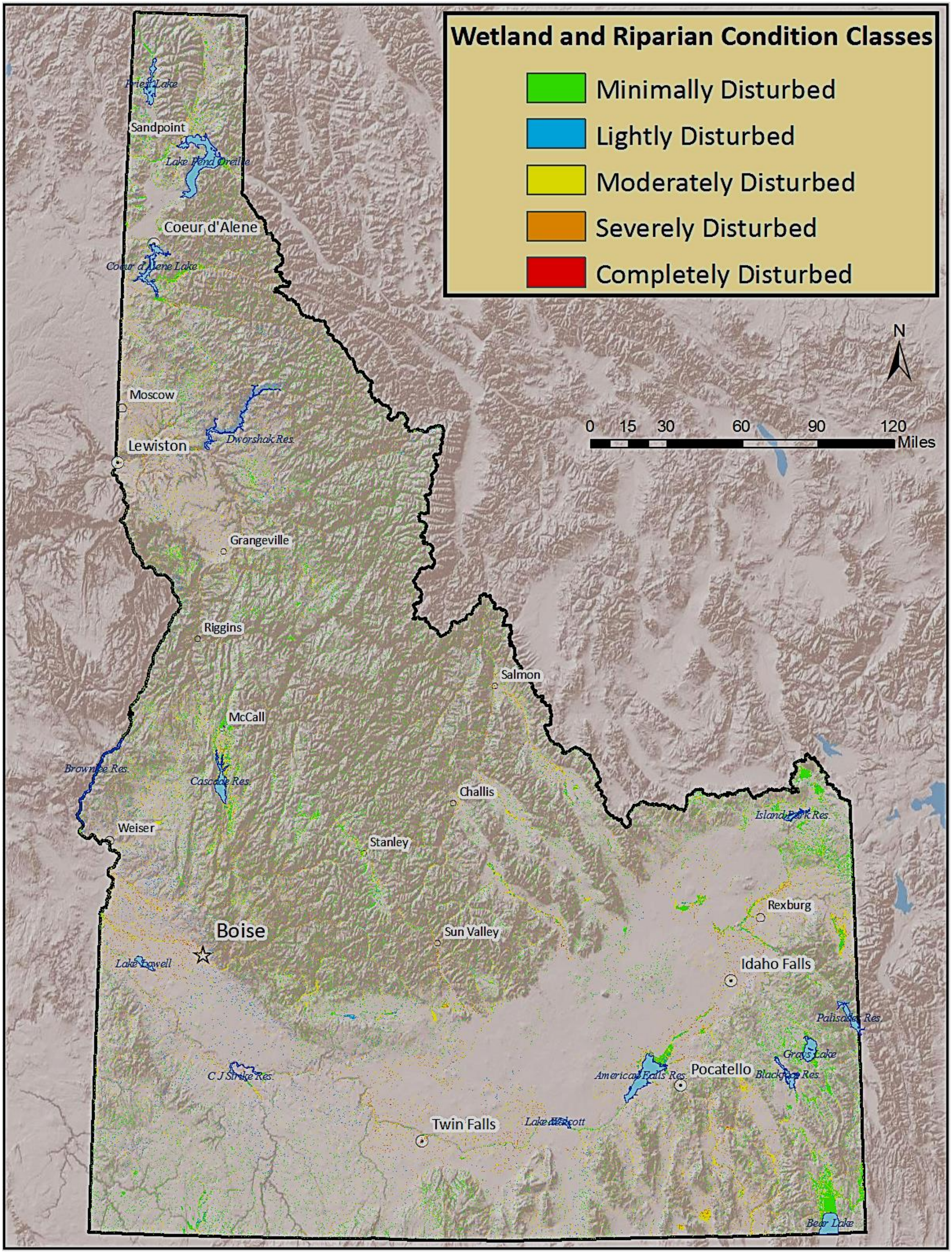


Figure 7. Wetland and riparian habitat condition.

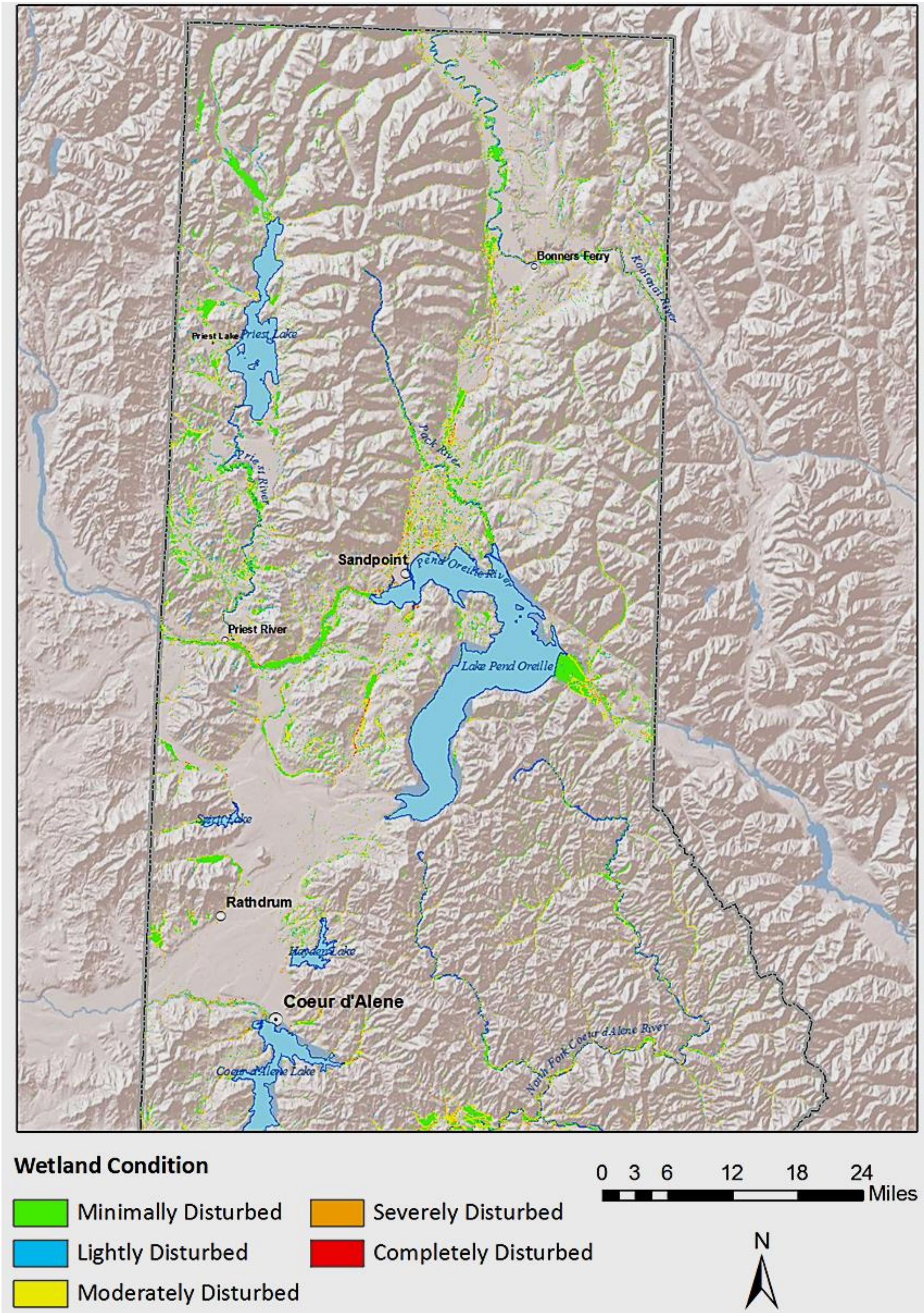


Figure 8. North-central and Panhandle wetland and riparian condition.

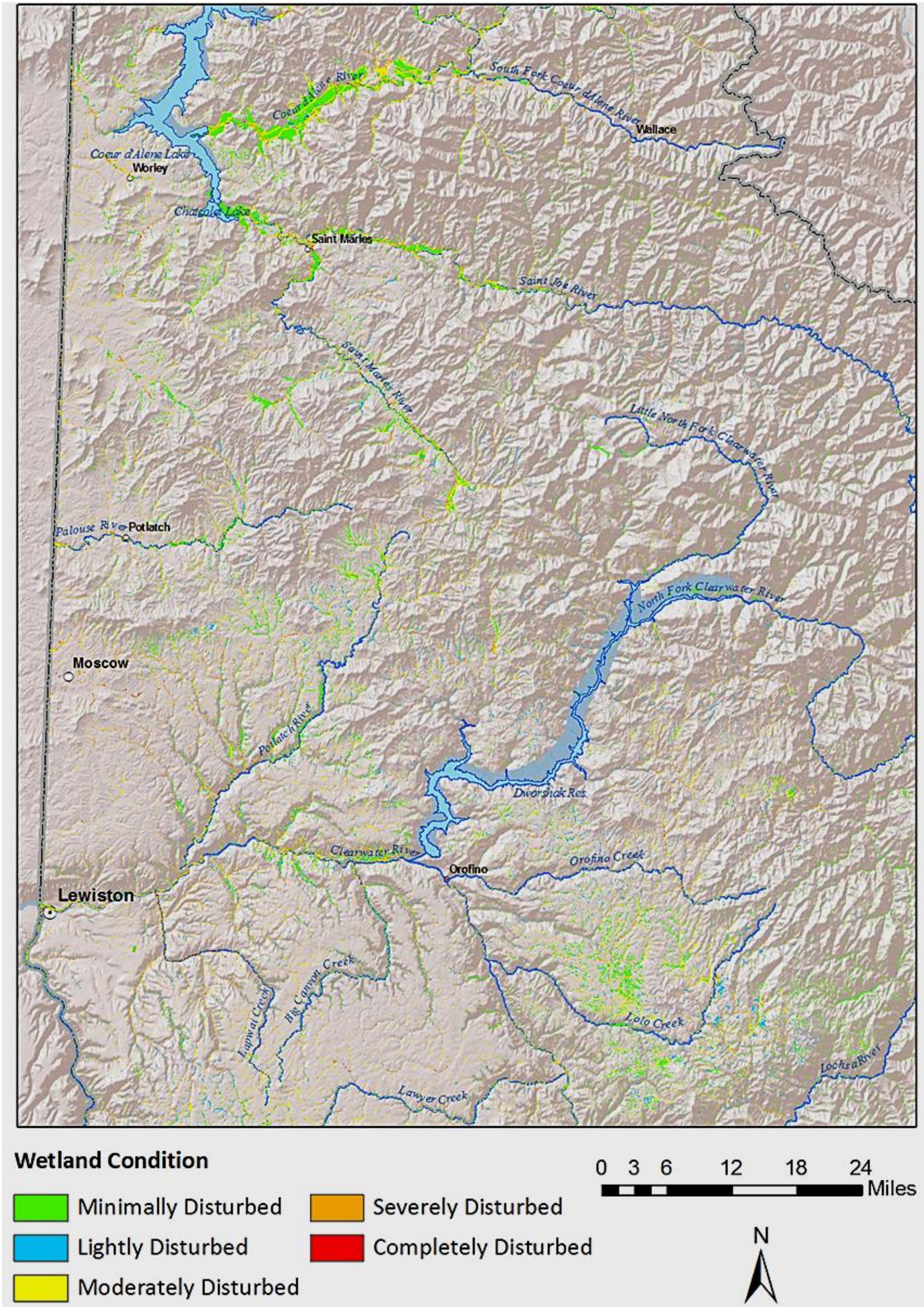


Figure 9. Palouse and Lower Clearwater Canyons - North-central wetland and riparian condition.

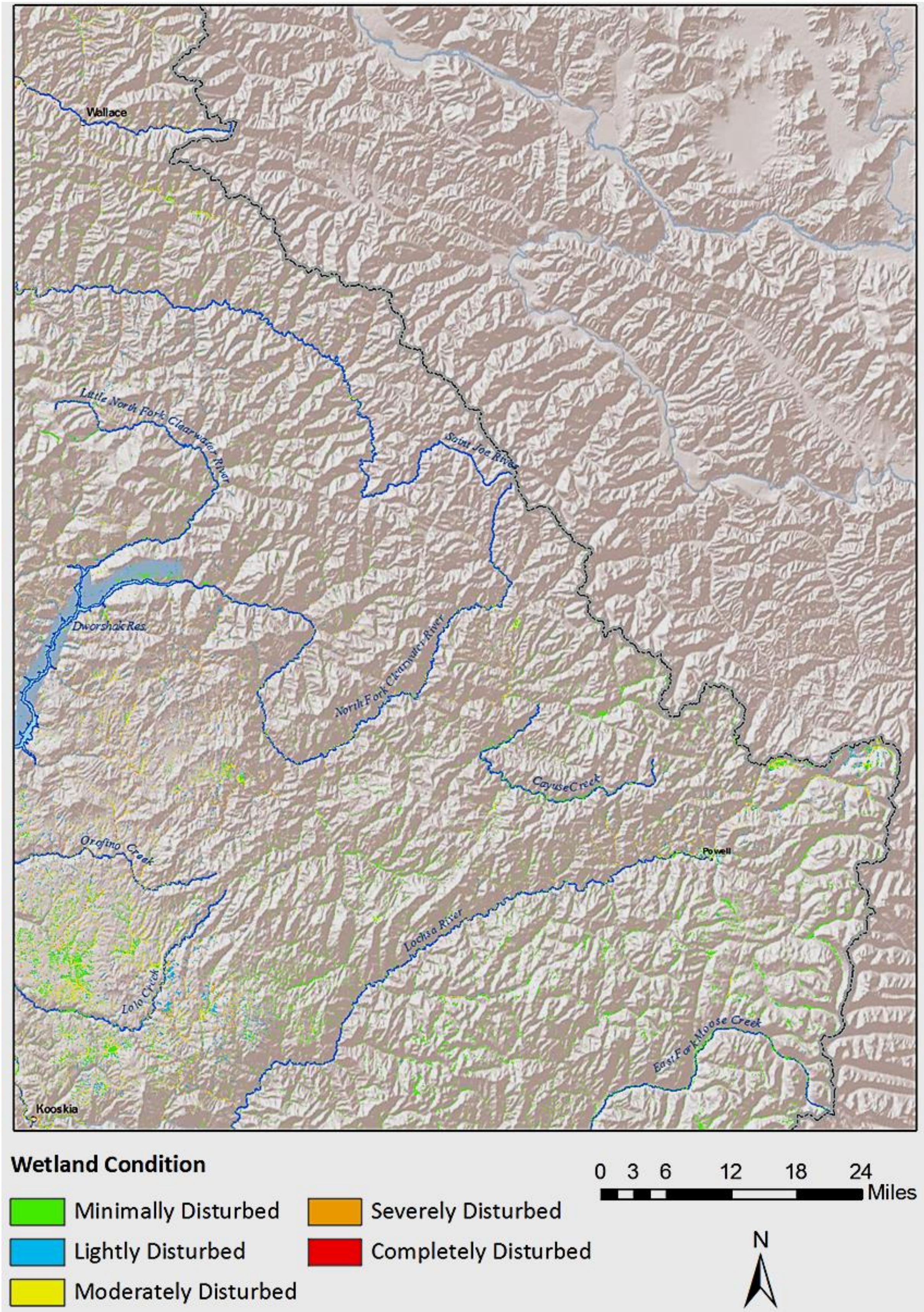


Figure 10. North-central Mountains wetland and riparian condition.

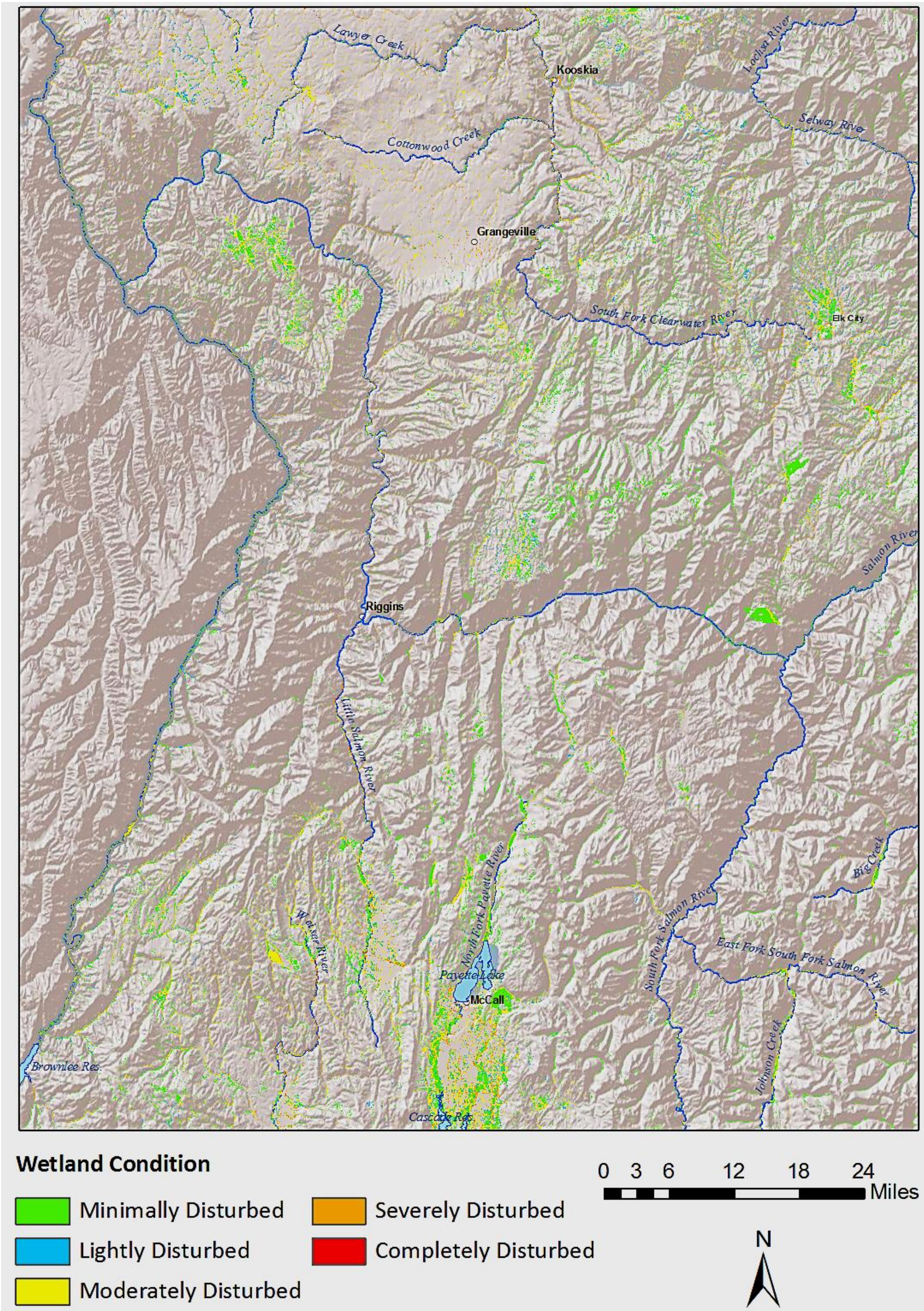


Figure 11. Blue Mountains and West-central wetland and riparian condition.

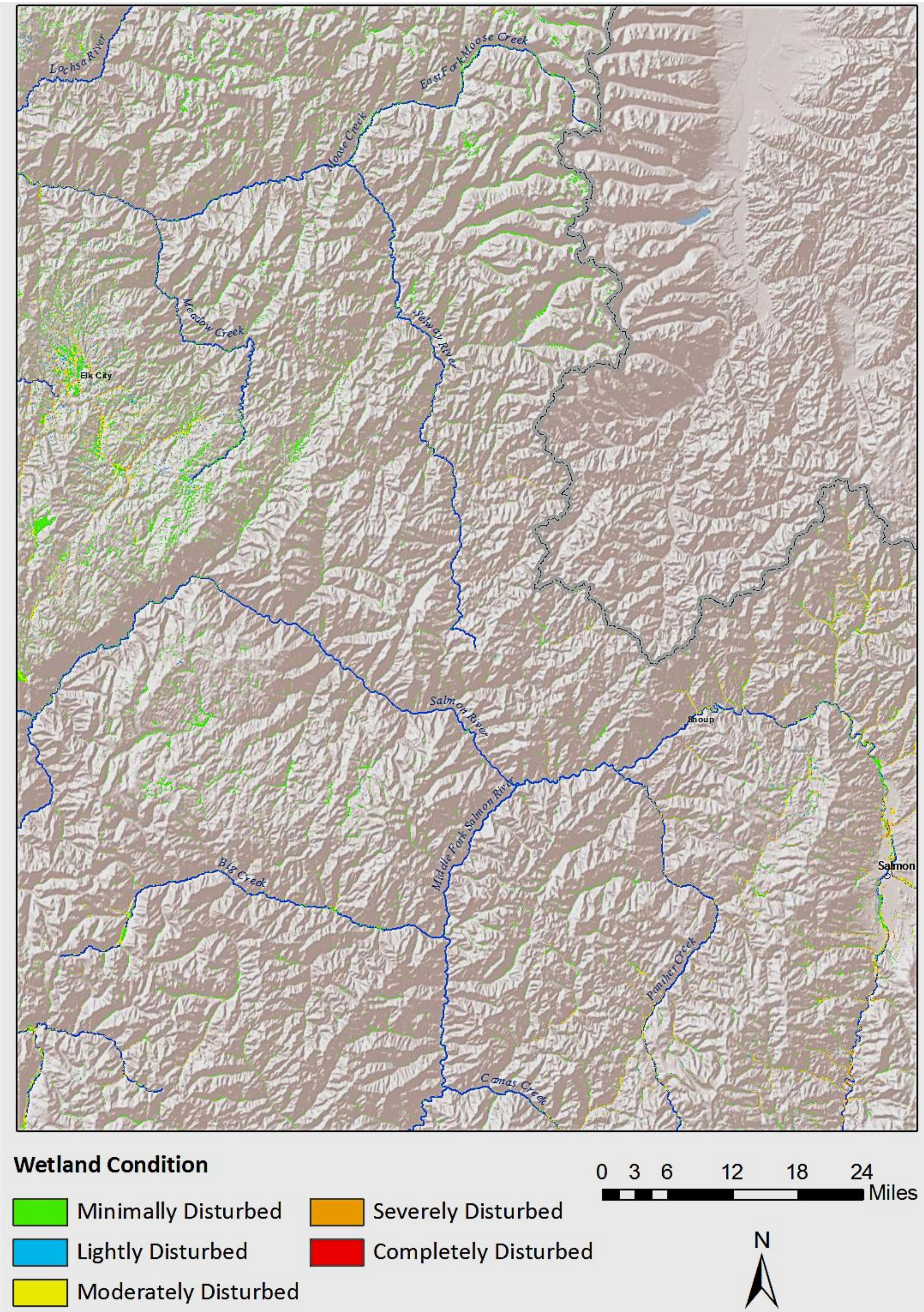


Figure 12. Central Batholith - Salmon River - Bitterroot Mountains wetland and riparian condition.

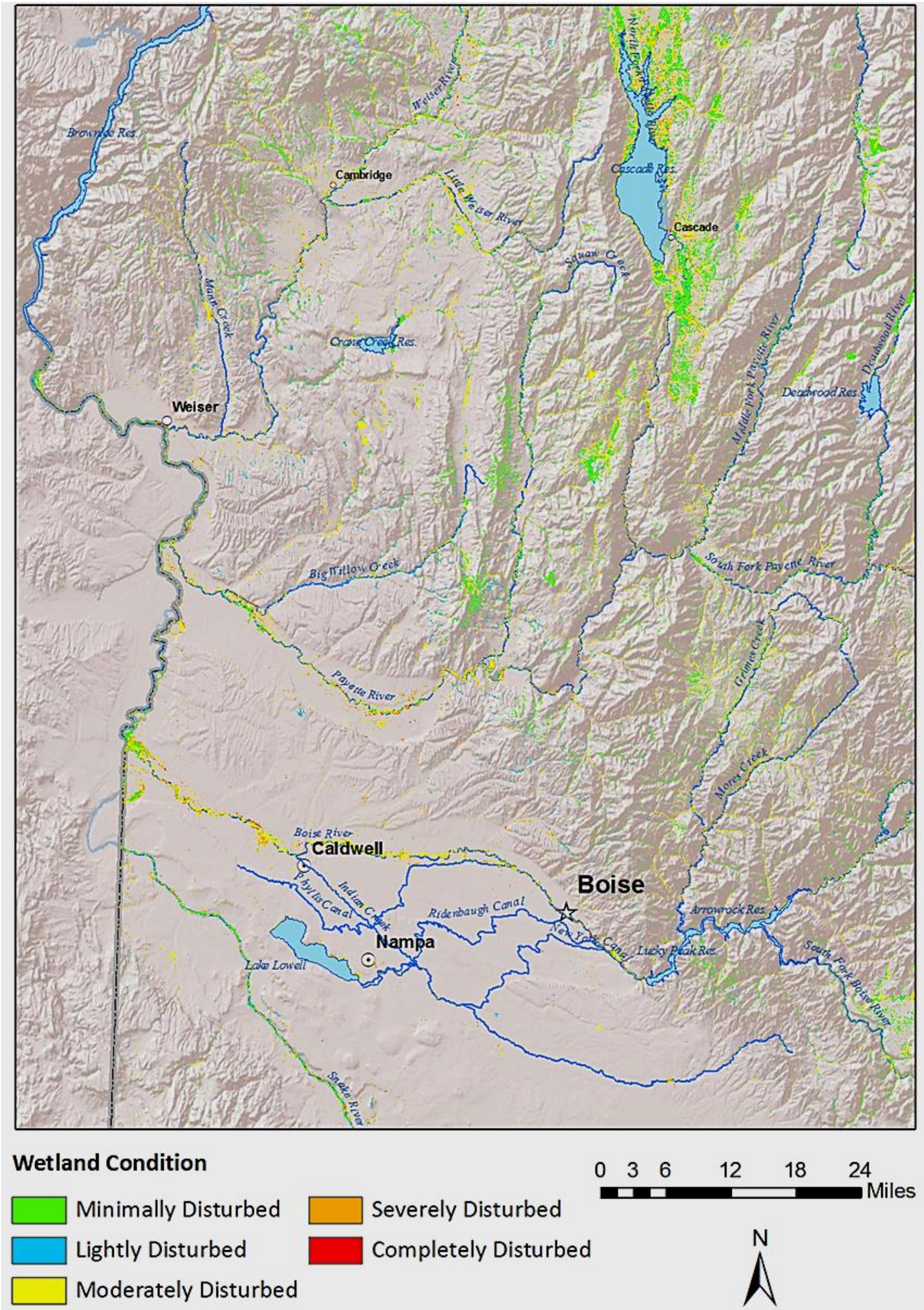


Figure 13. Blue Mountains and Lower Snake River Plain wetland and riparian condition.

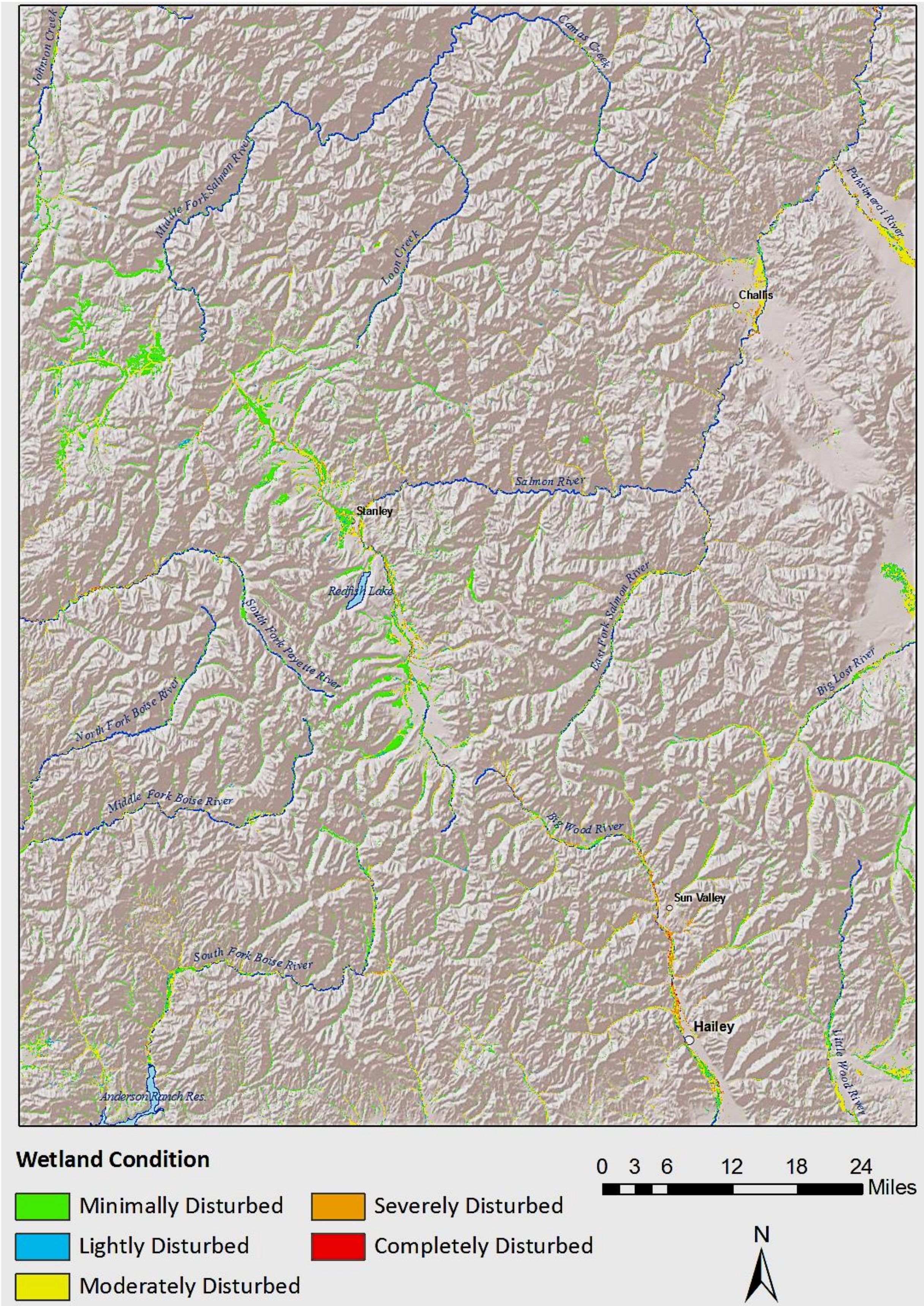


Figure 14. Central Batholith wetland and riparian condition.

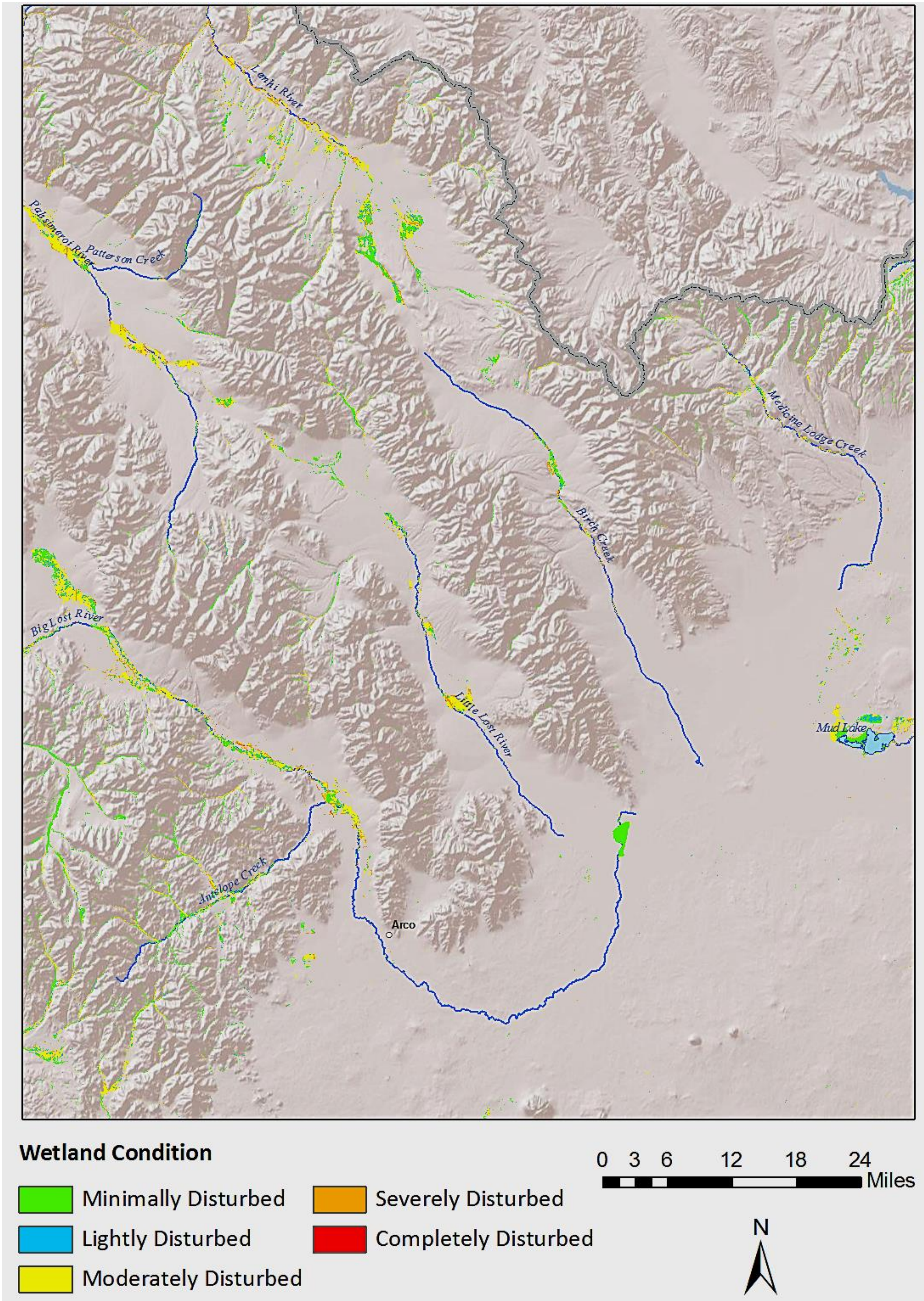


Figure 15. East-central Basin and Range wetland and riparian condition.

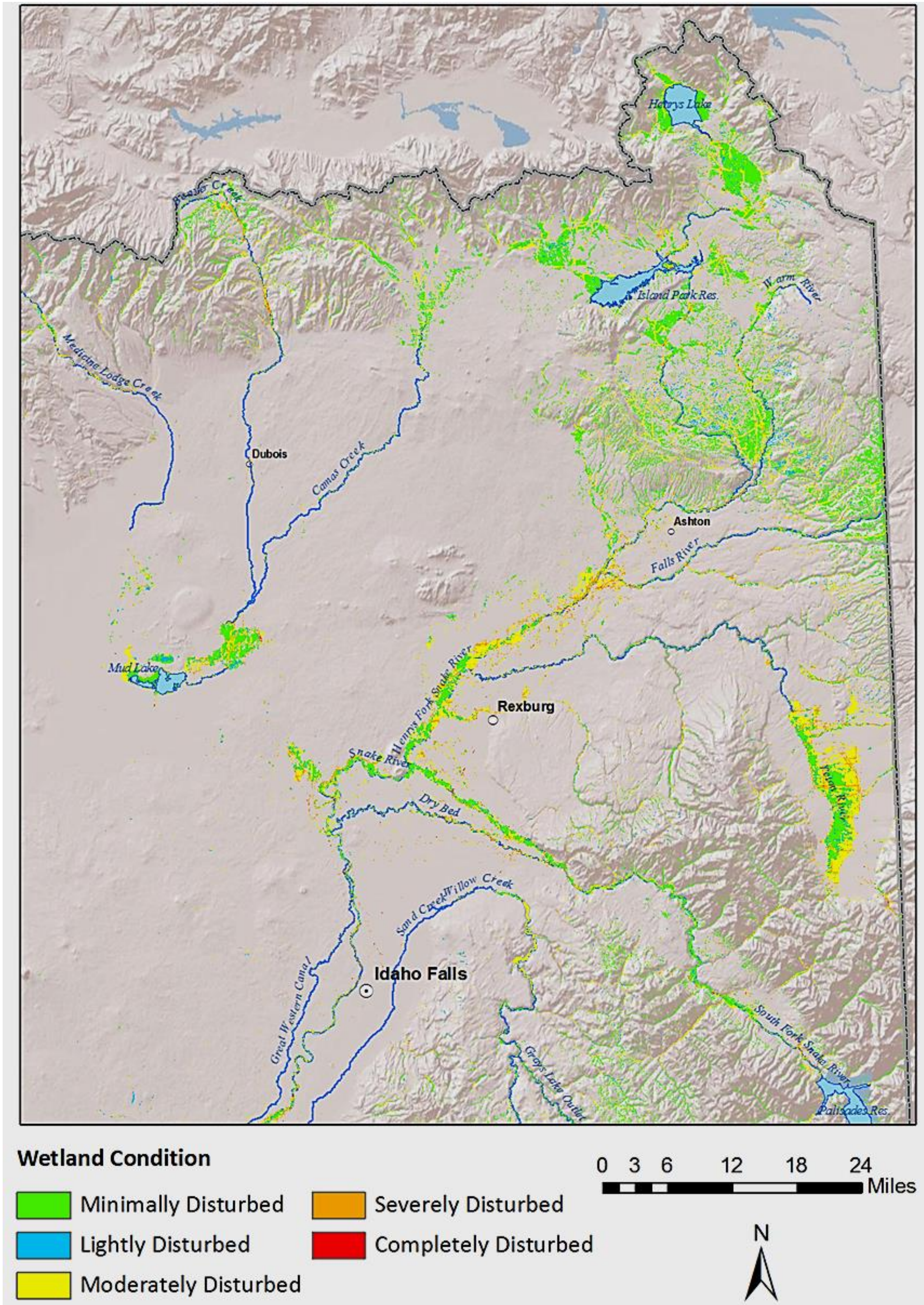


Figure 16. Upper Snake River Plain - Greater Yellowstone Plateau wetland and riparian condition.

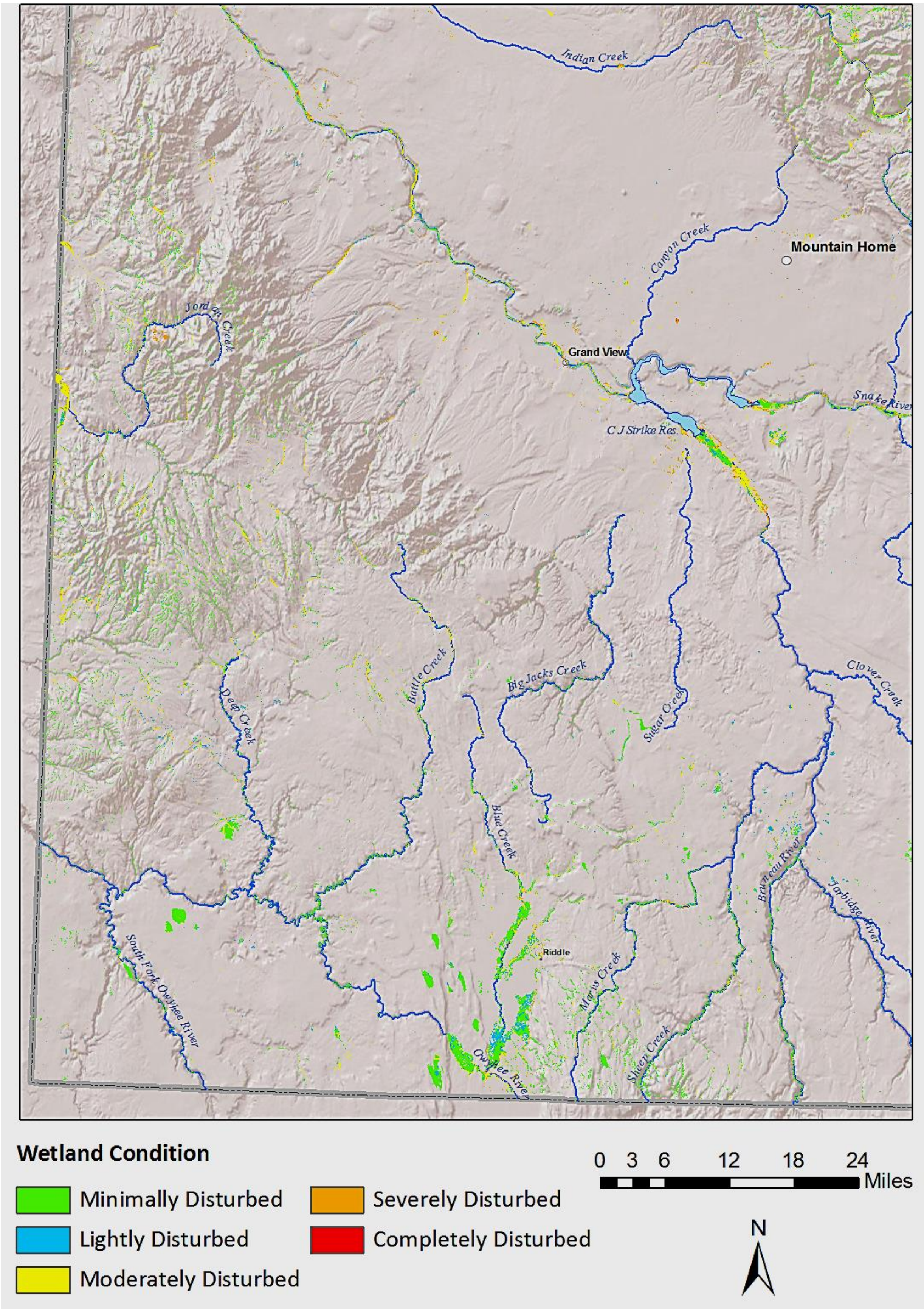


Figure 17. Owyhee Plateau & Mountains - Lower Snake River Plain wetland and riparian condition.

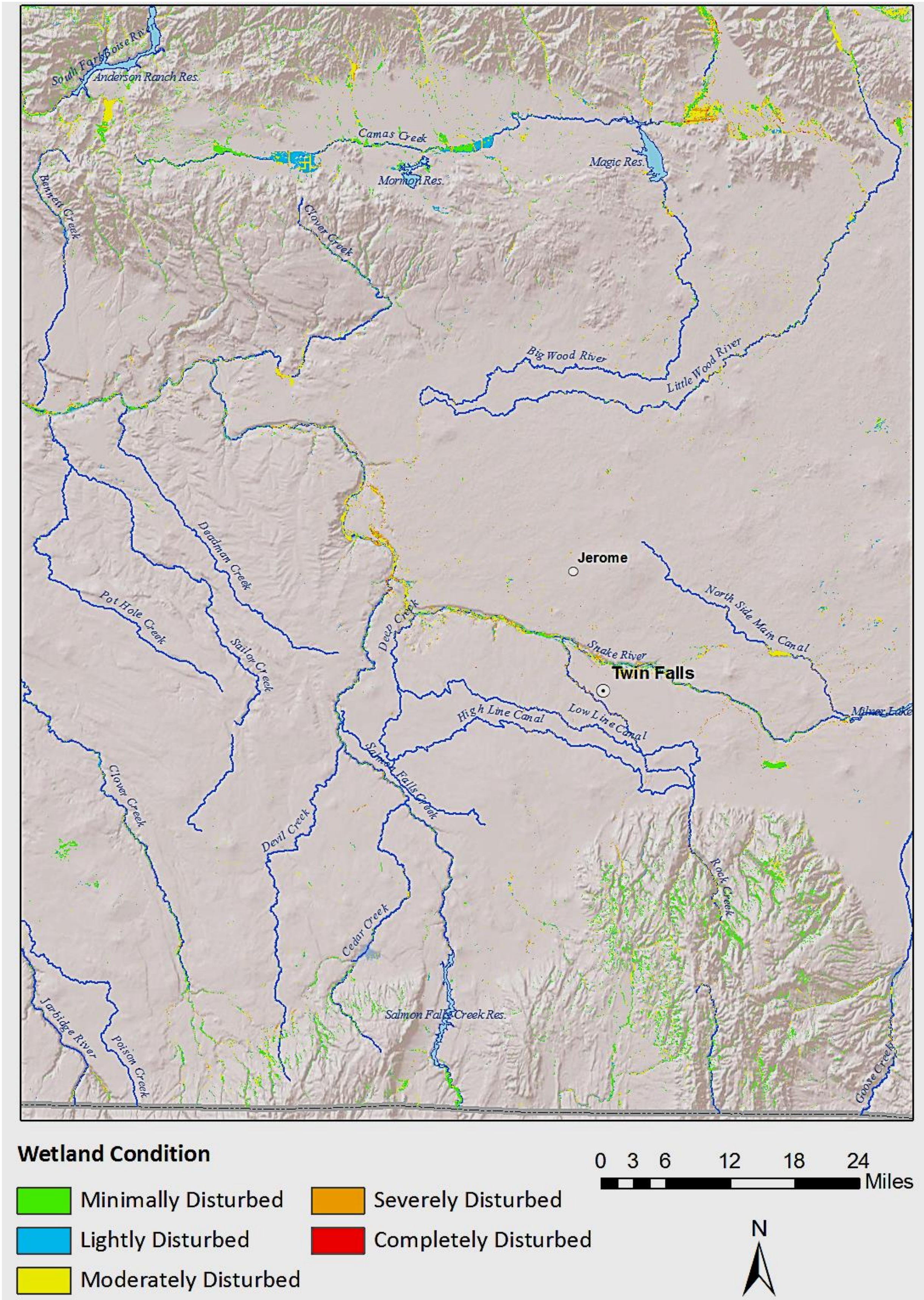


Figure 18. South-central - Middle Snake River Plain wetland and riparian condition.

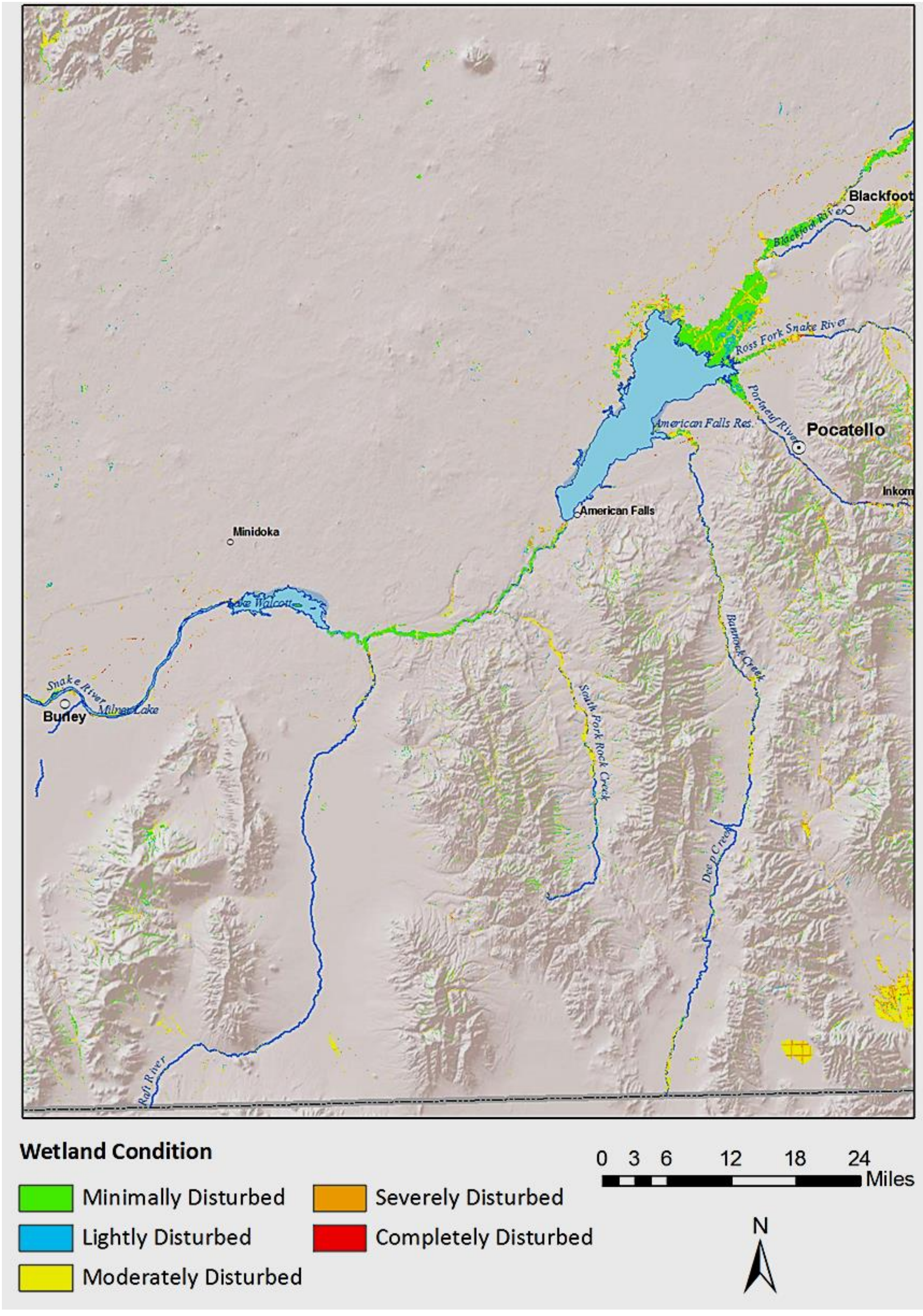


Figure 19. South-central Mountains and Upper Snake River Plain wetland and riparian condition.

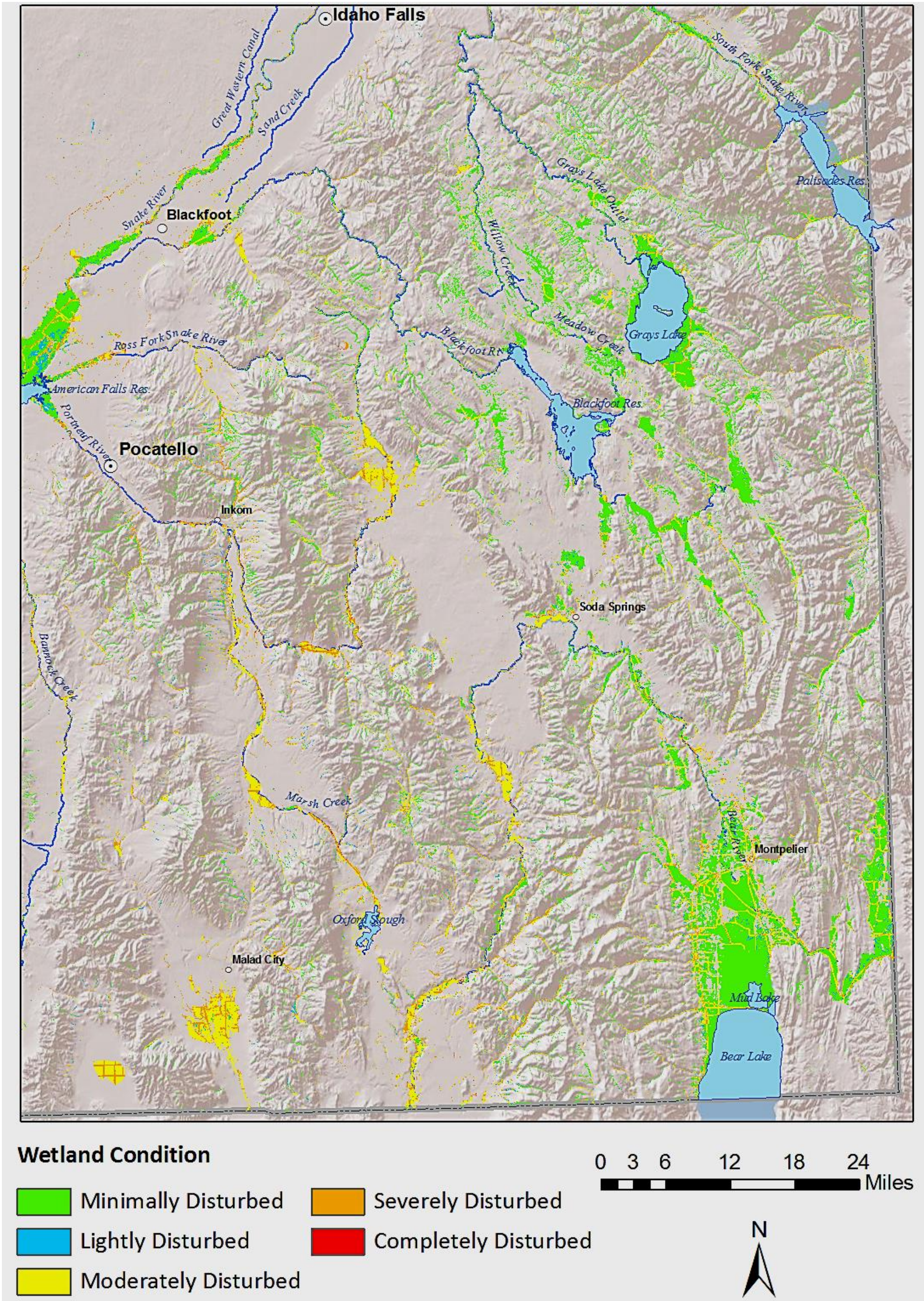


Figure 20. Southeast Basin and Range wetland and riparian condition.

MANAGEMENT IMPLICATIONS

Landscape-scale assessment tool strengths and weaknesses

The Phase II predictive model of wetland and riparian condition developed for this project is a significant advancement over Phase I (Murphy and Schmidt 2010). Based on our results, condition ranking appears logical for most of wetlands and riparian habitats. Results of condition ranking are a first-cut estimate and should not be used to make final management decisions (Weller et al. 2007). Although our current landscape-scale assessment model does not meet the original goal of 75% accuracy in predicting wetland condition, the tool does succeed in objectively establishing a statewide baseline estimate of condition.

Landscape-scale assessments typically yield variable estimates of ecological condition at watershed and wetland scales (Hychka et al. 2007, Wardrop et al. 2007, Weller et al. 2007, Vance 2009, Lemly et al. 2011). Because of this, they should not be used in lieu of on-the-ground assessments. Also, metrics used in this project to develop the model of predictive condition do not imply cause and effect between factors and condition (Hychka et al. 2007). In addition, we did not utilize a full range of possible tools that might strengthen the predictive model, such as Classification and Regression Tree (CART) analysis as in Wardrop et al. (2007), Weller et al. (2007), and Vance (2009). Statistical methods, including CART and others, could be applied in future iterations of this assessment tool to examine covariance between metrics, better identify breaks in condition classes, and refine weighting for metrics. In addition, our cutoff of 100 m, beyond which land use and stressor effects were treated as negligible in the model, does not imply that wetlands located beyond 100 m are not affected by some land uses or stressors (Vance 2009, Lemly et al. 2011, Comer and Hak 2012).

The strength of landscape-scale assessment arises from its ability to calculate numerous metrics from large datasets for many wetlands at one time (Vance 2009). However, numerous sources of potential error can influence both model development and outputs. For example, NWI, NLCD, NW ReGAP, and other spatial layers contain accuracy errors and become out-of-date as land use and management activities change more rapidly than the layers are updated (Weller et al. 2007, Vance 2009). Secondly, some site specific disturbances and indicators, such as livestock grazing and noxious weed or highly invasive plant species invasion, are not mapped well (Vance 2009). Third, the rapid assessment methods used in the accuracy assessment, while suitable for observing stressors and land uses that are related to landscape-scale metrics, have not been thoroughly tested. They are based on expert judgment and are adaptations of other rapid assessment methods. Except for limited analysis by Murphy and Schmidt (2010), metrics used in the Idaho Wetland Condition Rapid Assessment Method have not been thoroughly tested for their correlation with intensively collected, site-specific biologic data.

Landscape-scale wetland assessments operate on the assumption that land use and human disturbances influence ecological condition at specific wetland sites. Although a large number of metrics are significantly correlated with wetland condition, correlations are sometimes weak and may not provide enough information to create a robust and accurate model (Murphy and Schmidt 2010). Other metrics expected to be powerful indicators of wetland condition are not always significantly correlated (Hychka et al. 2007, Mita et al. 2007), Troelstrup and Stueven 2007, Weller et al. 2007 Vance 2009, Murphy and Schmidt 2010). This likely influences the outputs of landscape integrity models in complex ways not examined by this study.

Weller et al. (2007), Vance (2009), and Murphy and Schmidt (2010) hypothesize that landscape-scale assessment results can also be influenced by environmental variables (e.g., elevation, precipitation, slope, wetland size, stream density). In this project and prior studies, the types and number of important metrics are highly variable, stressing the value of using statistical tools to determine which metrics are important in a landscape-scale assessment. As in Vance (2009), regional differences, both in model development and resulting outputs may occur (Murphy and Schmidt 2010). One way to compare wetlands across regions might be to assess all wetlands at one time with the same metrics, but to weigh the most important metrics for a region more heavily for wetlands in that region. We also observed regional differences in the accuracy of our landscape-scale wetland assessment tool.

Outcomes

Idaho's landscape-scale wetland assessment tool enables stakeholders with limited resources to conduct a broad-scale assessment of wetland condition for the purpose of planning conservation, mitigation, restoration, and creation projects. Application of the wetland assessment tool in 5 case studies provided examples of how landscape-scale wetland condition information can support wetland conservation and restoration planning decisions across Idaho. By working with a land trust, there is an example of a process by which other land conservation groups can use the tool to identify, assess, and prioritize high quality and vulnerable wetlands for protection. Similarly, partnerships with both IDFG and non-governmental habitat conservation organizations show how information on landscape-scale wetland condition can be used to develop conservation and restoration strategies necessary for planning and funding site-specific projects. By working with state agency and local governments, examples of how landscape-scale assessment results can be applied in comprehensive land use or watershed planning efforts, including determining suitability of wetlands for mitigation. Local government planning efforts can be strengthened by identifying the most important wetland resources in urbanizing areas.

This project facilitated broad-scale assessment by partners. In the case studies, the resulting assessment outputs can be used as a baseline for long-term monitoring of wetland condition. For example, using historical wetland maps, county and state agencies can use tool results to compare past distribution, abundance, and condition of wetland types with the present situation. Areas currently lacking wetlands where expected can be targeted for wetland creation or restoration. This will help plan projects that result in a net wetland increase.

Projected outcomes from disseminating this refined GIS application for statewide landscape-scale assessment include:

- enhanced federal, state, tribal, and local capacity to incorporate wetland protection into planning;
- refined and coordinated wetland protection and restoration that prevents net loss and potentially increases wetland acreage and function;
- improved wetland comparisons, allowing for monitoring and conservation consistent with objectives;
- extended assessment and monitoring budgets;
- assessment, monitoring, and restoration targeted toward high priority or vulnerable wetlands;
- increased capacity to set mitigation objectives;
- a GIS tool complements future development of an Idaho-specific rapid assessment method;
- improved knowledge of Idaho's wetlands

Applications

This landscape-scale assessment tool is already being used to assist federal, state, tribal, and local organizations in the development and implementation of wetland projects. For example, the tool is being applied in watershed restoration planning in the Upper Coeur d'Alene River subbasin by tribal and state agencies. The tool has been used to highlight wetland condition in the Priest Lake and Pend Oreille Lake basins. In southwest Idaho, Idaho Department of Environmental Quality (IDEQ) has used it to identify reference stands of black cottonwood (*Populus balsamifera* ssp. *trichocarpa*) riparian vegetation in minimally or lightly disturbed condition. The tool is being used by IDFG to assess the condition of wetland and riparian habitats on its Wildlife Management Areas to improve its wetland program plan and meet site-specific planning needs.

This assessment tool is useful for targeting assessment and monitoring efforts towards vulnerable wetland resources at broad spatial scales (Wardrop et al. 2007). This is especially true for organizations lacking funding for more intensive assessments and monitoring. Planners and managers are now able to analyze the distribution of wetland impacts across broad areas. For example, IDEQ has expressed interest in incorporating landscape-scale assessment methods into future revisions of their Surface Water Ambient Monitoring Plan required under the Clean Water Act. In high priority regions, the condition of similar wetland types can be compared. Monitoring and conservation can then be tailored to meet specific objectives. When combined with watershed profiles or hydrogeomorphic analysis, information resulting from landscape-scale assessment can be combined with functional assessment to plan wetland protection, restoration, and mitigation with a watershed approach. For example, US Army Corps of Engineers, ITD, IDFG, and other governmental agencies can use the tool to identify ecologically suitable mitigation, restoration, and acquisition sites. The tool is currently being applied to investigate potential mitigation sites for a proposed bridge construction project in the South Fork Boise River watershed. Using historic wetland maps, the tool can also be used to compare past distribution, abundance, and condition of wetland types on the landscape with the present situation. Areas currently lacking wetlands where expected, based on past distribution, can be targeted for wetland restoration or creation. Specific types of wetlands to target can also be identified. Through these and other applications, this project aids in the design of projects that result in a net increase in wetland area and function for Idaho.

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- Pam Elkovich, Trout Unlimited
- Rick Just, Idaho Department of Parks and Recreation
- Rita Dixon, Wildlife Diversity Program, IDFG
- Steve Botti, City of Stanley

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APPENDIX 1

Reference wetland condition—rapidly assessed condition ranks and condition rank predicted by landscape-scale assessment tool

Assessment Date	Assessment Site Name	Project	Omernik Level III Ecoregion	HUC4 SUBBASIN NAME	HGM Class	Phase I Landscape Tool (Murphy and Schmidt 2010) Predicted Condition	Phase II Landscape Tool Predicted Condition	Idaho Wetland Condition Rapid Assessment Rank	U. S. A. Wetland Condition Rapid Assessment Rank
9/8/2011	NWCA11-ID-0015	IWCA	Middle Rockies	BEAR LAKE	Riverine Complex		minimally		lightly (moderately)
9/7/2011	NWCA11-ID-0084	IWCA	Northern Basin and Range	LAKE WALCOTT	Riverine Upper Perennial		moderately		moderately (severely)
8/30/2011	NWCA11-ID-0044	IWCA	Middle Rockies	LITTLE LOST	Slope Topographic		moderately		lightly (moderately)
9/13/2011	NWCA11-ID-0068	IWCA	Middle Rockies	LITTLE LOST	Slope Topographic		moderately		lightly (moderately)
8/10/2011	NWCA11-ID-0062	IWCA	Idaho Batholith	LITTLE SALMON	Riverine Upper Perennial		minimally (moderately)		minimally
7/14/2011	NWCA11-ID-0031	IWCA	Northern Rockies	PRIEST	Lacustrine Fringe Natural	moderately	minimally		minimally
7/13/2011	NWCA11-ID-0018	IWCA	Northern Rockies	PRIEST	Slope Topographic	severely	minimally (moderately)		minimally
7/15/2011	NWCA11-ID-0059	IWCA	Northern Rockies	UPPER NORTH FORK CLEARWATER	Riverine Lower Perennial		moderately		lightly
10/21/2008	Rose Lake - Coeur D'Alene WMA	Landscape Tool - Phase I	Northern Rockies	COEUR D'ALENE LAKE	slope / depressional / riverine / lacustrine fringe	severely	minimally (moderately)	lightly (moderately)	
10/21/2008	Coeur D'Alene - Fernan Lake	Landscape Tool - Phase I	Northern Rockies	COEUR D'ALENE LAKE	depressional	severely	completely	moderately (severely)	
10/24/2008	Old Town Subdivision	Landscape Tool - Phase I	Northern Rockies	LITTLE SPOKANE	slope	severely	minimally (lightly)	moderately (severely)	
10/22/2008	Clark Fork Airstrip	Landscape Tool - Phase I	Northern Rockies	LOWER CLARK FORK	slope	severely	moderately	lightly (moderately)	
10/22/2008	Kootenai NWR - IDL Parcel	Landscape Tool - Phase I	Northern Rockies	LOWER KOOTENAI	depressional	minimally	moderately	minimally (moderately)	
10/23/2008	Farm to Market Road - Slope	Landscape Tool - Phase I	Northern Rockies	LOWER KOOTENAI	slope	moderately	severely	lightly (moderately)	
10/22/2008	Deep Creek - Kootenai River Confluence - Kootenai NWR	Landscape Tool - Phase I	Northern Rockies	LOWER KOOTENAI	riverine	severely	moderately (severely)	moderately	
10/22/2008	Deep Creek - Kootenai River Boat Launch	Landscape Tool - Phase I	Northern Rockies	LOWER KOOTENAI	upland	completely	moderately	severely (completely)	

Assessment Date	Assessment Site Name	Project	Omernik Level III Ecoregion	HUC4 SUBBASIN NAME	HGM Class	Phase I Landscape Tool Predicted Condition	Phase II Landscape Tool Predicted Condition	Idaho Wetland Rapid Assessment Rank	U. S. A. Wetland Rapid Assessment Rank
10/23/2008	US Highway 95 - Meadow	Landscape Tool - Phase I	Northern Rockies	MOYIE	depressional	moderately	severely	lightly (moderately)	
10/23/2008	Round Prairie Forest	Landscape Tool - Phase I	Northern Rockies	MOYIE	riverine	completely	moderately (severely)	severely	
10/7/2008	Squaw Butte	Landscape Tool - Phase I	Snake River Plain	PAYETTE	upland	minimally	minimally	minimally	
10/7/2008	Paddock Valley Reservoir	Landscape Tool - Phase I	Snake River Plain	PAYETTE	slope	moderately	moderately (lightly)	moderately (severely)	
10/24/2008	Freeman Lake	Landscape Tool - Phase I	Northern Rockies	PEND OREILLE	lacustrine deep water	severely	minimally (moderately)	minimally (moderately)	
10/24/2008	Pend Oreille River - Stateline Oxbow	Landscape Tool - Phase I	Northern Rockies	PEND OREILLE	depressional	severely	minimally	minimally (moderately)	
10/22/2008	Grouse Creek	Landscape Tool - Phase I	Northern Rockies	PEND OREILLE LAKE	riverine	minimally	moderately (minimally)	minimally	
10/21/2008	Careywood - Blacktail Road	Landscape Tool - Phase I	Northern Rockies	PEND OREILLE LAKE	depressional	severely	moderately	moderately	
10/22/2008	Upper Pack River - Forest	Landscape Tool - Phase I	Northern Rockies	PEND OREILLE LAKE	riverine	moderately	moderately (severely)	moderately	
10/23/2008	Priest River Marsh	Landscape Tool - Phase I	Northern Rockies	PEND OREILLE LAKE	depressional	completely	severely	moderately	
10/23/2008	Sagle Road	Landscape Tool - Phase I	Northern Rockies	PEND OREILLE LAKE	slope	severely	moderately	moderately (severely)	
10/23/2008	Priest River - USFS Fen	Landscape Tool - Phase I	Northern Rockies	PRIEST	depressional	minimally	minimally (lightly)	minimally	
10/23/2008	Priest River - Campsite	Landscape Tool - Phase I	Northern Rockies	PRIEST	depressional	minimally	minimally	minimally	
10/23/2008	Priest Lake Airport	Landscape Tool - Phase I	Northern Rockies	PRIEST	depressional	moderately	minimally	lightly	
10/23/2008	Lower West Branch Priest River	Landscape Tool - Phase I	Northern Rockies	PRIEST	riverine	severely	severely	lightly (moderately)	
10/23/2008	Priest River - Commercial Buildings and Parking Lots	Landscape Tool - Phase I	Northern Rockies	PRIEST	upland	completely	severely	severely (completely)	
10/21/2008	Pinehurst - S Fk Coeur D'Alene River Trail	Landscape Tool - Phase I	Northern Rockies	SOUTH FORK COEUR D'ALENE	depressional	minimally	moderately	minimally	
10/21/2008	Pinehurst - Parking Lot	Landscape Tool - Phase I	Northern Rockies	SOUTH FORK COEUR D'ALENE	depressional	severely	severely (completely)	severely	

Assessment Date	Assessment Site Name	Project	Omernik Level III Ecoregion	HUC4 SUBBASIN NAME	HGM Class	Phase I Landscape Tool Predicted Condition	Phase II Landscape Tool Predicted Condition	Idaho Wetland Rapid Assessment Rank	U. S. A. Wetland Rapid Assessment Rank
10/21/2008	N Fk Coeur D'Alene River - Forest	Landscape Tool - Phase I	Northern Rockies	UPPER COEUR D'ALENE	riverine	moderately	moderately	minimally (moderately)	
10/8/2008	Middle Fork Weiser River	Landscape Tool - Phase I	Idaho Batholith	WEISER	riverine	moderately	moderately	minimally (moderately)	
10/20/2008	Tamarack Mill Pond	Landscape Tool - Phase I	Blue Mountains	WEISER	depressional	moderately	severely	moderately (severely)	
9/8/2011	Elk Creek Reference Reach (ELCR 01)	Landscape Tool - Phase II	Idaho Batholith	BOISE-MORES	riverine		minimally	minimally	
9/8/2011	Elk Creek Reference Reach (ELCR 02)	Landscape Tool - Phase II	Idaho Batholith	BOISE-MORES	riverine		minimally	minimally (moderately)	
9/23/2011	Mores Creek Riparian Restoration Reach (MORE 04, MORE 05, MORE 06)	Landscape Tool - Phase II	Idaho Batholith	BOISE-MORES	riverine		minimally	lightly	
9/20/2011	Mores Creek Riparian Restoration Reach (MORE 02, MORE 03)	Landscape Tool - Phase II	Idaho Batholith	BOISE-MORES	riverine		moderately (minimally)	lightly	
7/26/2011	Grimes Creek Reference Reach (GRIM 02, GRIM 03, GRIM 04, GRIM05)	Landscape Tool - Phase II	Idaho Batholith	BOISE-MORES	riverine		moderately	lightly (moderately)	
7/26/2011	Mores Creek Reference Reach (MORE 01)	Landscape Tool - Phase II	Idaho Batholith	BOISE-MORES	riverine		severely (moderately)	lightly (moderately)	
9/30/2008	Bruneau River Delta - CJ Strike WMA	Landscape Tool - Phase II	Snake River Plain	BRUNEAU	depressional / slope	minimally	moderately (minimally)	minimally	
9/30/2008	Bruneau River - CJ Strike WMA	Landscape Tool - Phase II	Snake River Plain	BRUNEAU	depressional	minimally	moderately (minimally)	minimally (moderately)	
9/30/2008	Hot Creek Ranch - CJ Strike WMA	Landscape Tool - Phase II	Snake River Plain	BRUNEAU	mineral soil flat	moderately	minimally	minimally (moderately)	
9/30/2008	Bruneau River	Landscape Tool - Phase II	Snake River Plain	BRUNEAU	riverine	moderately	lightly	lightly	
10/1/2008	CJ Strike - Crane Falls Farm Pond	Landscape Tool - Phase II	Snake River Plain	BRUNEAU	depressional	moderately	severely	severely	
10/1/2008	Long Tom - Prairie Road Seeps	Landscape Tool - Phase II	Idaho Batholith	C. J. STRIKE RESERVOIR	slope	moderately	moderately	lightly (moderately)	
10/1/2008	Long Tom - Prairie Road Springs	Landscape Tool - Phase II	Snake River Plain	C. J. STRIKE RESERVOIR	slope	moderately	moderately	lightly (moderately)	

Assessment Date	Assessment Site Name	Project	Omernik Level III Ecoregion	HUC4 SUBBASIN NAME	HGM Class	Phase I Landscape Tool Predicted Condition	Phase II Landscape Tool Predicted Condition	Idaho Wetland Rapid Assessment Rank	U. S. A. Wetland Rapid Assessment Rank
10/1/2008	Rattlesnake Creek Reservoir	Landscape Tool - Phase II	Snake River Plain	C. J. STRIKE RESERVOIR	depressional	severely	moderately (severely)	moderately	
10/1/2008	Flying H Canal - South of Mountain Home	Landscape Tool - Phase II	Snake River Plain	C. J. STRIKE RESERVOIR	slope	severely	moderately (severely)	moderately (severely)	
9/2/2011	Lloyd Wetland	Landscape Tool - Phase II	Snake River Plain	LAKE WALCOTT	depressional		moderately (lightly)	minimally (moderately)	
6/29/2011	NWCA11-ID-0012	Landscape Tool - Phase II	Snake River Plain	LOWER BOISE	Riverine Human Altered	moderately	moderately		lightly (moderately)
9/17/2008	Barber Pool Conservation Area - Surprise Valley Subdivision	Landscape Tool - Phase II	Snake River Plain	LOWER BOISE	depressional	moderately	severely (completely)	lightly	
9/19/2008	Camel's Back Park	Landscape Tool - Phase II	Snake River Plain	LOWER BOISE	slope	moderately	moderately	lightly	
10/2/2008	US Highway 95 - Boise River Bridge	Landscape Tool - Phase II	Snake River Plain	LOWER BOISE	depressional	moderately	completely	moderately	
9/19/2008	US Highway 20 - Sod Farm	Landscape Tool - Phase II	Snake River Plain	LOWER BOISE	upland	severely	severely	severely	
11/5/2010	Eagle Island Wetland Mitigation	Landscape Tool - Phase II	Snake River Plain	LOWER BOISE	depressional	severely	moderately	lightly (moderately)	
11/5/2010	Hyatt Hidden Lakes Reserve	Landscape Tool - Phase II	Snake River Plain	LOWER BOISE	depressional / slope	moderately	severely (moderately)	moderately (severely)	
11/5/2010	Fivemile - Victory Wetland	Landscape Tool - Phase II	Snake River Plain	LOWER BOISE	depressional		severely	severely	
10/29/2010	Alta Harris Ranch Side Channel - Boise River	Landscape Tool - Phase II	Snake River Plain	LOWER BOISE	riverine / slope	severely	severely (moderately)	severely	
10/15/2010	Glenn Wetland	Landscape Tool - Phase II	Snake River Plain	LOWER BOISE	depressional	moderately	moderately (severely)	severely	
9/29/2010	Chester Wetlands - Sand Creek WMA	Landscape Tool - Phase II	Snake River Plain	LOWER HENRYS	depressional		moderately	lightly (moderately)	
10/2/2008	Fort Boise WMA	Landscape Tool - Phase II	Snake River Plain	MIDDLE SNAKE-PAYETTE	depressional	severely	minimally	lightly (moderately)	
10/2/2008	Whitley Road Marsh	Landscape Tool - Phase II	Snake River Plain	MIDDLE SNAKE-PAYETTE	depressional	severely	severely	lightly (moderately)	
7/29/2010	Jewel Wetland	Landscape Tool - Phase II	Snake River Plain	MIDDLE SNAKE-PAYETTE	depressional	moderately	moderately (severely)	moderately	

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10/9/2008	Halverson Lake Springs	Landscape Tool - Phase II	Snake River Plain	MIDDLE SNAKE-SUCCOR	slope	moderately	moderately	minimally (moderately)	
10/9/2008	Walters Ferry - Highway 45	Landscape Tool - Phase II	Snake River Plain	MIDDLE SNAKE-SUCCOR	depressional	moderately	severely (moderately)	lightly	
10/9/2008	Rabbit Springs	Landscape Tool - Phase II	Snake River Plain	MIDDLE SNAKE-SUCCOR	depressional	minimally	severely	lightly (moderately)	
10/9/2008	Con Shea - Livestock Reservoir	Landscape Tool - Phase II	Snake River Plain	MIDDLE SNAKE-SUCCOR	depressional	severely	lightly	moderately	
10/6/2010	Succor Creek Wetland	Landscape Tool - Phase II	Snake River Plain	MIDDLE SNAKE-SUCCOR	depressional	moderately	moderately	severely	
7/7/2011	NWCA11-3300	Landscape Tool - Phase II	Idaho Batholith	NORTH FORK PAYETTE	Depression Open		minimally		minimally
8/11/2011	NWCA11-1501	Landscape Tool - Phase II	Idaho Batholith	NORTH FORK PAYETTE	Depression Open		minimally		minimally (lightly)
7/6/2011	NWCA11-1501	Landscape Tool - Phase II	Idaho Batholith	NORTH FORK PAYETTE	Depression Open		minimally		lightly
7/17/2011	NWCA11-3312	Landscape Tool - Phase II	Idaho Batholith	NORTH FORK PAYETTE	Riverine Human Altered		lightly (minimally)		lightly (moderately)
9/10/2011	NWCA11-ID-0045	Landscape Tool - Phase II	Middle Rockies	PALISADES	Riverine Lower Perennial		moderately		lightly (moderately)
9/29/2010	Rainey Creek	Landscape Tool - Phase II	Middle Rockies	PALISADES	depressional / riverine		moderately	moderately	
9/30/2010	Garden Creek - Conant Valley Ranch	Landscape Tool - Phase II	Middle Rockies	PALISADES	riverine / slope		minimally	severely	
10/6/2008	Payette River WMA	Landscape Tool - Phase II	Snake River Plain	PAYETTE	depressional	moderately	minimally	lightly	
10/6/2008	New Plymouth Farm	Landscape Tool - Phase II	Snake River Plain	PAYETTE	upland	severely	severely	severely	
8/25/2011	NWCA11-1489	Landscape Tool - Phase II	Idaho Batholith	SOUTH FORK PAYETTE	Riverine Lower Perennial		minimally		minimally
9/19/2011	NWCA11-3310	Landscape Tool - Phase II	Idaho Batholith	SOUTH FORK PAYETTE	Slope Topographic		minimally		minimally
7/25/2011	NWCA11-1489	Landscape Tool - Phase II	Idaho Batholith	SOUTH FORK PAYETTE	Riverine Lower Perennial		minimally		minimally
7/27/2011	NWCA11-3292	Landscape Tool - Phase II	Idaho Batholith	SOUTH FORK PAYETTE	Riverine Lower Perennial		minimally		minimally

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7/26/2011	NWCA11-3303	Landscape Tool - Phase II	Idaho Batholith	SOUTH FORK PAYETTE	Riverine Complex		minimally		minimally (lightly)
7/5/2011	NWCA11-ID-0020	Landscape Tool - Phase II	Idaho Batholith	SOUTH FORK SALMON	Riverine Complex		minimally		minimally
8/23/2011	NWCA11-1504	Landscape Tool - Phase II	Idaho Batholith	SOUTH FORK SALMON	Slope Topographic		lightly (minimally)		minimally
8/22/2011	NWCA11-1514	Landscape Tool - Phase II	Idaho Batholith	SOUTH FORK SALMON	Slope Topographic		moderately		minimally
8/24/2011	NWCA11-3291	Landscape Tool - Phase II	Idaho Batholith	SOUTH FORK SALMON	Slope Topographic		moderately		minimally
10/20/2010	Vest Sundown River Ranch North - Teton River	Landscape Tool - Phase II	Snake River Plain	TETON	depressional / slope		minimally (lightly)	moderately	
10/21/2010	Klausman Lazy K Ranch	Landscape Tool - Phase II	Snake River Plain	TETON	depressional / slope		moderately	moderately	
10/19/2010	Bailie Sundown Ranch South - Teton River	Landscape Tool - Phase II	Snake River Plain	TETON	depressional / slope		minimally (moderately)	moderately (severely)	
10/19/2010	Cooke Warm Creek Ranch	Landscape Tool - Phase II	Snake River Plain	TETON	depressional / riverine / slope		moderately	severely	
8/16/2011	NWCA11-ID-0069	Landscape Tool - Phase II	Middle Rockies	UPPER HENRYS	Riverine Complex		lightly		minimally (lightly)
10/2/2009	Town Park Road Lower Seep	Landscape Tool - Phase II	Idaho Batholith	UPPER SALMON	slope		severely	lightly	
10/2/2009	Town Park Road Upper Seep	Landscape Tool - Phase II	Idaho Batholith	UPPER SALMON	slope		severely	lightly	
10/2/2009	Highway 75 Between Airport and Highway	Landscape Tool - Phase II	Idaho Batholith	UPPER SALMON	depressional / slope		severely	lightly (moderately)	
10/2/2009	Highway 75 Riverside Information Kiosk	Landscape Tool - Phase II	Idaho Batholith	UPPER SALMON	slope		severely (moderately)	moderately	
10/10/2009	Highway 75 Riverside Across From Museum	Landscape Tool - Phase II	Idaho Batholith	UPPER SALMON	slope		severely	moderately	
10/9/2009	Valley Creek - upstream of town	Landscape Tool - Phase II	Idaho Batholith	UPPER SALMON	riverine / slope / depressional		minimally (lightly)	moderately	
10/10/2009	Stanley Ranger Station Museum	Landscape Tool - Phase II	Idaho Batholith	UPPER SALMON	depressional / slope		severely (completely)	moderately (severely)	
10/2/2009	Highway 75 Riverside Hotsprings	Landscape Tool - Phase II	Idaho Batholith	UPPER SALMON	slope		severely	severely	

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10/2/2009	Highway 21 - Highway 75 Junction Riverside	Landscape Tool - Phase II	Idaho Batholith	UPPER SALMON	slope		severely	severely	
10/9/2009	Valley Creek - town section	Landscape Tool - Phase II	Idaho Batholith	UPPER SALMON	riverine / slope / depressional		moderately (severely)	severely (completely)	
10/1/2009	Meadow Creek	Landscape Tool - Phase II	Idaho Batholith	UPPER SALMON	slope / riverine		minimally (severely)	completely	
10/1/2009	Unnamed drainage south of town	Landscape Tool - Phase II	Idaho Batholith	UPPER SALMON	slope		severely (moderately)	completely	
10/14/2011	Spring Cove Ranch	Landscape Tool - Phase II	Snake River Plain	UPPER SNAKE-ROCK	depressional		moderately	moderately	
9/15/2011	College of Southern Idaho Wetland - Perrine Coulee	Landscape Tool - Phase II	Snake River Plain	UPPER SNAKE-ROCK	depressional		moderately (severely)	severely	
11/3/2010	LQ Drain	Landscape Tool - Phase II	Snake River Plain	UPPER SNAKE-ROCK	depressional		moderately (severely)	severely (completely)	
10/8/2010	Wrightman Wetland	Landscape Tool - Phase II	Snake River Plain	WEISER	depressional	moderately - severely	severely (moderately)	moderately (severely)	
9/9/2011	NWCA11-ID-0001	Landscape Tool - Phase II	Northern Basin and Range	WILLOW	Depression Open		minimally		lightly
9/11/2011	NWCA11-ID-0066	Landscape Tool - Phase II	Middle Rockies	WILLOW	Riverine Upper Perennial		moderately		severely (completely)
9/13/2006	Middle Fork Clearwater River - Nez Perce Indian Reservation - Kooskia Fish Hatchery	Middle-S. Fk. Clearwater	Northern Rockies	MIDDLE FORK CLEARWATER	riverine				
9/21/2006	Middle Fork Clearwater River - Swan Creek to Lowell Riverine	Middle-S. Fk. Clearwater	Idaho Batholith	MIDDLE FORK CLEARWATER	riverine				
8/31/2006	East Fork Crooked River Headwaters	Middle-S. Fk. Clearwater	Idaho Batholith	SOUTH FORK CLEARWATER	slope		minimally	minimally	
9/6/2006	Upper American River Meadows	Middle-S. Fk. Clearwater	Idaho Batholith	SOUTH FORK CLEARWATER	riverine / slope		minimally	minimally	
8/11/2006	Silver Creek - China Point Sloped Wetlands	Middle-S. Fk. Clearwater	Idaho Batholith	SOUTH FORK CLEARWATER	slope		minimally	minimally	
9/3/2006	Kay Creek	Middle-S. Fk. Clearwater	Idaho Batholith	SOUTH FORK CLEARWATER	riverine		minimally (lightly)	minimally (moderately)	
8/12/2006	Lower Twentymile Meadows	Middle-S. Fk. Clearwater	Idaho Batholith	SOUTH FORK CLEARWATER	slope / riverine		minimally (moderately)	minimally (moderately)	

Assessment Date	Assessment Site Name	Project	Omernik Level III Ecoregion	HUC4 SUBBASIN NAME	HGM Class	Phase I Landscape Tool Predicted Condition	Phase II Landscape Tool Predicted Condition	Idaho Wetland Rapid Assessment Rank	U. S. A. Wetland Rapid Assessment Rank
8/10/2006	McComas Meadows	Middle-S. Fk. Clearwater	Idaho Batholith	SOUTH FORK CLEARWATER	riverine / slope		moderately (minimally)	lightly	
9/5/2006	Upper Red River - Red River Hotsprings Meadows	Middle-S. Fk. Clearwater	Idaho Batholith	SOUTH FORK CLEARWATER	slope / riverine		moderately (minimally)	lightly	
9/5/2006	Upper Red River - Red River Ranger Station	Middle-S. Fk. Clearwater	Idaho Batholith	SOUTH FORK CLEARWATER	riverine / slope		moderately (severely)	lightly	
9/1/2006	Tenmile Creek Sloped Wetlands	Middle-S. Fk. Clearwater	Idaho Batholith	SOUTH FORK CLEARWATER	slope		minimally	minimally	
9/15/2006	Elk Creek - Elk City Meadows	Middle-S. Fk. Clearwater	Idaho Batholith	SOUTH FORK CLEARWATER	riverine / slope				
9/14/2006	Middle Red River - Red River WMA	Middle-S. Fk. Clearwater	Idaho Batholith	SOUTH FORK CLEARWATER	riverine / slope / depressional				
8/29/2011	NWCA11-3309	NWCA	Idaho Batholith	LITTLE WOOD	Riverine Complex		minimally		minimally (lightly)
7/12/2011	NWCA11-1511	NWCA	Northern Rockies	MOYIE	Riverine Complex	moderately	minimally		minimally
8/9/2011	NWCA11-3297	NWCA	Northern Rockies	UPPER NORTH FORK CLEARWATER	Riverine Upper Perennial		minimally		minimally
7/15/2011	Deyo Reservoir	Restored Wetlands	Northern Rockies	CLEARWATER	depressional / riverine / slope		minimally (lightly)	moderately	
9/22/2010	Chapman Wetland	Restored Wetlands	Northern Rockies	CLEARWATER	depressional		minimally (moderately)	moderately	
10/4/2011	Worley - North Fork Rock Creek Wetland Mitigation	Restored Wetlands	Columbia Plateau	HANGMAN	riverine / slope		moderately (severely)	moderately	
9/24/2010	Round Valley Creek	Restored Wetlands	Idaho Batholith	LITTLE SALMON	riverine / slope / depressional		minimally	moderately (severely)	
7/20/2011	Ball Creek TNC Preserve Wetland	Restored Wetlands	Northern Rockies	LOWER KOOTENAI	depressional / slope	moderately - severely	moderately	moderately	
9/21/2010	Kaler Easement - Telcher Creek Wetland	Restored Wetlands	Columbia Plateau	LOWER SALMON	depressional		moderately (severely)	lightly (moderately)	
9/1/2011	Franklin Wetland Mitigation	Restored Wetlands	Central Basin and Range	MIDDLE BEAR	depressional / slope		severely	severely	

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9/27/2011	Genesee - Cow Creek Wetland Mitigation	Restored Wetlands	Columbia Plateau	PALOUSE	riverine / slope		moderately (severely)	lightly (moderately)	
9/14/2011	Carol Ryrie Brink Nature Park	Restored Wetlands	Columbia Plateau	PALOUSE	riverine / slope		severely	lightly (moderately)	
9/20/2011	South Fork Palouse River	Restored Wetlands	Columbia Plateau	PALOUSE	riverine / slope		severely	moderately	
9/11/2011	Streets Wetland	Restored Wetlands	Columbia Plateau	PALOUSE	depressional / slope		severely	moderately	
8/18/2011	Price Road - McCammon Wetland Mitigation	Restored Wetlands	Northern Basin and Range	PORTNEUF	depressional		moderately	moderately	
8/31/2011	Sacajawea Park - Portneuf River	Restored Wetlands	Snake River Plain	PORTNEUF	depressional / slope		severely	severely	
7/19/2011	Bismark Meadows Wetland	Restored Wetlands	Northern Rockies	PRIEST	depressional / slope	severely - moderately	minimally	minimally (moderately)	
9/22/2011	Threemile Creek	Restored Wetlands	Columbia Plateau	SOUTH FORK CLEARWATER	riverine / slope		severely (moderately)	moderately	
7/18/2011	Hauser Lake	Restored Wetlands	Northern Rockies	UPPER SPOKANE	depressional	severely	moderately (minimally)	lightly (moderately)	

IWCA = Idaho Wetland Condition Assessment
Landscape Tool - Phase I = Landscape-scale Wetland Assessment Tool - Phase I (Murphy and Schmidt 2010)
Landscape Tool - Phase II= Landscape-scale Wetland Assessment Tool - Phase II (current project)
Middle-S. Fk. Clearwater = Middle Fork - South Fork Clearwater Wetland Inventory
NWCA = National Wetland Condition Assessment
Restored Wetlands = Assessment of Restored, Enhanced, and Created Wetlands